Surface Mine Waste
in
Cherokee County, Kansas

May 22, 1988

Gary Andes
P.O. Box 893
Cannon Beach, OR 97110

Introduction

Under the authority of CERCLA and SARA, the U.S. Environmental Protection Agency has been studying an area known as the Cherokee County Superfund site in southeast Kansas, an area of former lead-zinc mining. The site has been subdivided by EPA into six subsites as shown in Figure 1 (from the Galena Subsite OUFS). To date only the Galena Subsite has been studied in detail by EPA and Operable Unit Feasibility Studies prepared. After considerable study, analysis, and evaluation of the Galena Subsite, EPA has proposed a remedial action alternative which would remove and treat the surface mine wastes. Surface mine wastes would be removed by excavation and then treated by milling and flotation processes to concentrate the lead and zinc for partial cost recovery. Tailing from the treatment process would be disposed of in the mine voids. Following surface mine waste removal, the disturbed land areas would be recontoured and vegetated.

Because only reconnaissance level studies have been performed at the other five subsites, it is not presently known what remedial action alternatives EPA might eventually propose for those areas, if any. However, a large factor to be considered in the evaluation of almost any alternative is the quantity of surface mine waste existing in the area. In addition, the breakdown of waste by type and the chemical composition of the wastes must be considered.

A previous study (April 4, 1988) was completed to evaluate the existing surface mine waste data and provided an estimate of the quantity and types of surface mine wastes within the eight zones delineated by EPA for the Galena Subsite. This second study was commissioned to perform a similar evaluation for the remaining subsites within the Cherokee County Superfund Site. Also surveyed were some outlying areas around

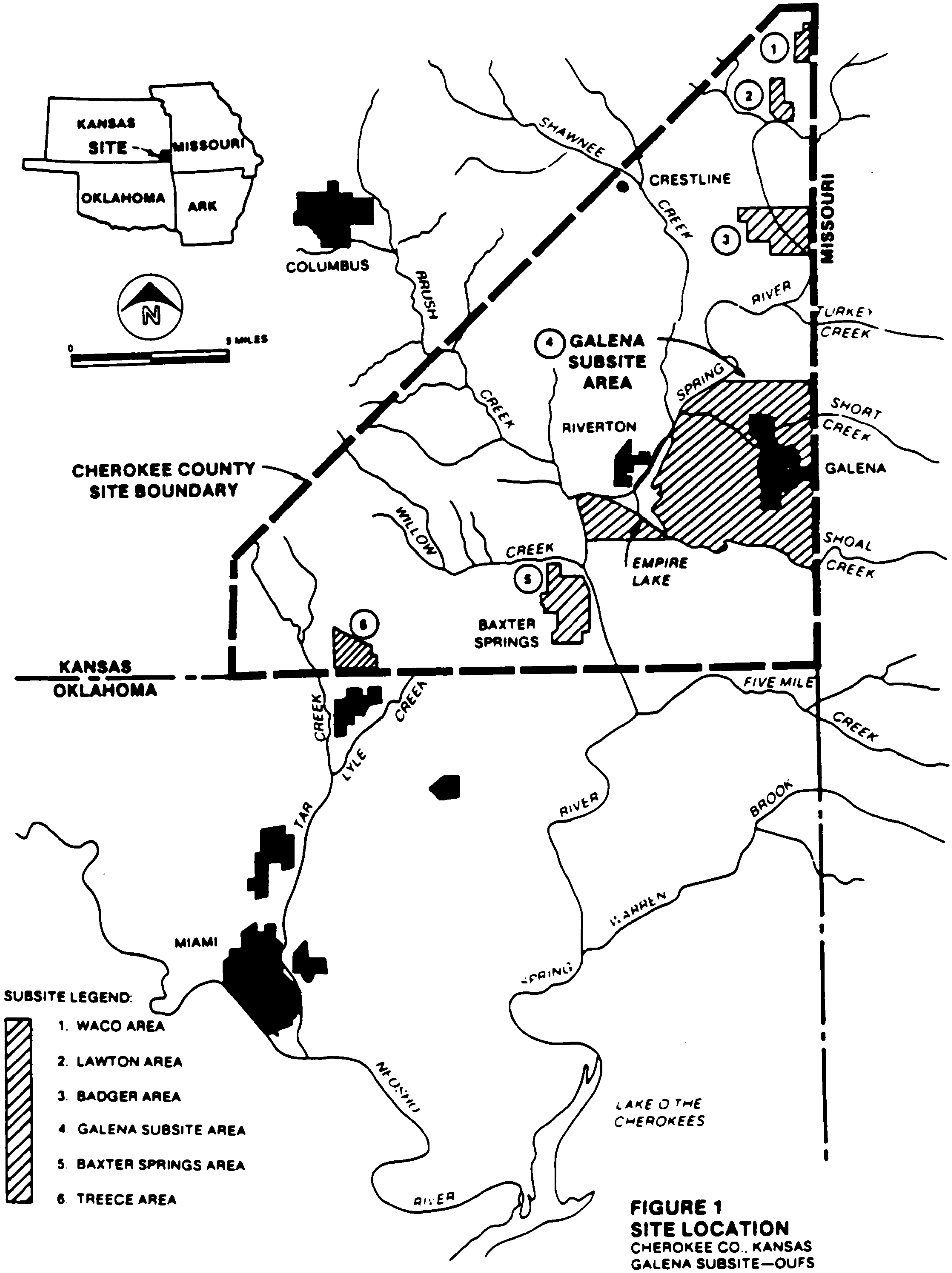


FIGURE 1
SITE LOCATION
CHEROKEE CO., KANSAS
GALENA SUBSITE—OUFS
GROUNDWATER/SURFACE WATER

Galena not included in the April 4, 1988 survey. Field work was conducted from May 14-19, 1988 with literature review and calculations occurring before and after the field work.

Surface Mine Waste Types

As defined by EPA, mine wastes is a collective term that includes bullrock, dump material, chat, slag, and tailing -- all derived from mining and smelter activities. In this study bullrock and dump material were combined into one category as waste rock. In addition, two additional waste types were identified and categorized, sand and stream sediments.

Bullrock is very coarse material and boulders removed in shaft excavation. Dump material is subeconomic ore from minus 1/4-inch to boulder size excavated from the subsurface workings and deposited on the surface in the process of mining. The two above materials are commonly mixed and are usually found adjacent to the mine shaft. Chat is a fine grained material, mostly chips of host rock, that has been milled to remove the sulfides. It is easily distinguished from the other waste materials by its smaller grain size and gray color (on the surface of the pile). Sand is an intermediate product in grain size between chat and the finer grained tailing. It appears as its name suggests and is usually gray in color also and sometimes mixed with the chat. Tailing is the finest grained of the waste materials, is usually light brown in color, and contained within a ponding system. Stream sediments are materials found in the area streambeds from the erosional process on any of the above materials and may consist of a mixture of the other waste types, although usually smaller sized in nature.

Procedures

Three major sources of data were utilized during the study. (1) USGS topographic maps for the areas; (2) 1978 aerial photos (black and white) obtained from the Soil Conservation Service; and (3) maps and data presented in the 1983 McCauley study of stability problems and hazard evaluations.

The McCauley maps and topo maps were utilized to generally outline the known locations of surface mine wastes. The aerial photos were then used in the field to outline and characterize in detail the surface mine waste areas in the six subsites according to the five waste types previously described.

Areal extent of each waste type was estimated by actually walking each zone and outlining areas on the aerial photos in the field. Visible known locations and reference points such as streets or roads, ponds, buildings, power lines, and streams were used to locate positions in the surface waste fields. Only a few locations were inaccessible due to "No Trespassing" signs. These areas were visually surveyed from roadways or railways and estimates of areal extent and depth made. In addition, a few locations were both inaccessible and not visible from any location. These areas were estimated from the aerial photos only and a three or six-inch depth utilized.

For individual piles an estimate of the average height was made as most piles were irregular in shape. Larger areas of mine waste were walked and an estimate of average waste depth over the area made. Where minimal piles existed in an area or the area had some natural surface showing, the depth was usually estimated at three inches. Areas with larger piles or minimal natural surface were estimated at six inches in depth. Ravines and washouts, as well as mine shafts and pits, were utilized to ascertain the natural surface level. Although the areas covered by this survey were generally flat in nature with only slighlty rolling topography, the slope of the natural topography was also taken into account when estimating pile or area waste depths. Areas with larger heaped piles and/or spreadout zones were usually estimated at one foot in depth. Some areas mapped contained essentially one pile whose dimensions were estimated as previously described. Depth estimates also attempted to include the minor surface and mine shaft depressions which contained some mine waste in the slumped or cone shapes.

Areas on the marked-up aerial photos were determined by planimeter by Allgeier, Martin & Associates of Joplin, Missouri to obtain acreage figures for each mine waste area and pond identified in the photographs.

Volumes for each area or pile were calculated using standard formulas from the dimensions estimated or measured in the field. Total subsite and waste type volumes were then calculated by summing the previously calculated volumes.

Interpretation of Results

Appendix A contains the marked up aerial photographs utilized to determine the areal extent of the various types of mine wastes located. Also included in Appendix A are index maps showing the locations of the aerial photographs. Appendix B contains the results of the planimetering and volume calculations for the areas.

Table 1 presents a summary of the number of locations of mine wastes located during this survey. Over 300 sites were located or delineated with over one-third being in the Treece area and 1/3 being in the Baxter Springs area. Chat piles or remnants constituted nearly 50% of the locations with waste rock piles making up another 31%.

Table 1

Number of Mine Waste Piles,
Remnants or Locations

Area	Rock	Chat*	Sand*	Tailing	Stream Sediment	Total
Baxter Springs	30	49	2	17	2	100
Galena (this survey)	8	15	-	-	1	24
Treece	38	52	13	19	1	123
Waco	6	11	1	4	-	22
Lawton	1	6	-	-	-	7
Badger	13	16	1	1	-	31
TOTAL	96	149	17	41	4	307

* In a few cases chat and sand were mixed together and were placed in the category felt to represent the majority of the material.

Table 2 presents a summary of the acreage of surface mine wastes by waste type and subsite location. Chat piles or remnants made up 74% of the acreage found during this survey with waste rock piles only accounting for 3%. When results of the previous Galena survey are included, the waste rock percentage increases to 19%, while chat drops to 63%. This is due to the much larger percentage of waste rock occurring in the Galena Subsite as a result of the more intense surface or near surface mining which occurred there. Of the total acreage, the Galena Subsite accounts for 39%, with Treece close behind at 34% and Baxter Springs a distant third at 17%.

The 1983 study by McCauley of mine and mill waste and disturbed areas yielded the data shown in Table 3 for each subsite area. A comparison of McCauley's areas shown in Appendix C with the Appendix A aerial photographs shows a generally close agreement regarding delineation of surface mine waste areas. The difference in estimated acreages probably is a function of the definition of waste coverage and the fact that areas which appear to be totally revegetated were not included in this survey. In addition, it is known that some of the surface mine waste has been removed or utilized (chat for roadways and fill, for example). Although only two chat piles were observed being actively utilized (BS10-C3 and T5-C2) during the survey, it appeared that at least eight others had been recently active and utilized as a resource by locals or sand and gravel companies. In any case, the 1,872 acre estimate is most likely on the low side.

Table 4 presents a summary of the estimated volumes of surface mine wastes by waste type and subsite. Approximately 7,600,000 cubic yards of surface mine waste were estimated to exist within the Cherokee County Superfund Site. Of the material located during this survey only 5% was waste rock

Table 2

Acreage of Mine Waste Types

Area	Rock	Chat	Sand	Tailing	Stream Sediment	Total	%
Baxter Springs	8.14	264.92	9.03	31.71	2.50	316.30	17
Galena	8.63	33.46	-	-	.61	42.70	
Treece	9.92	453.71	85.24	78.85	.94	628.66	34
Waco	.79	62.36	36.43	30.74	-	130.32	7
Lawton	.27	13.28	-	-	-	13.55	1
Badger	4.89	39.99	3.62	.10	-	48.60	3
TOTAL	32.64	867.72	134.32	141.40	4.05	1180.13	-
% of this Survey	3	74	11	12	-	100	-
Galena (previous survey)	320	312	-	-	60	692	37
GRAND TOTAL	353	1180	134	141	64	1872	100
PERCENTAGE	19	63	7	8	3	100	-

Table 3

Comparison of Acreages of Mine Wastes

	ACRES		
Area	McCauley Survey *	Andes Survey **	% Andes/ McCauley
Waco	150	130	87
Lawton	19	14	74
Badger/Crestline	72	49	68
Treece	747	629	84
Baxter Springs	449	316	70
Galena	891	735	82
TOTAL	2,328	1,873	80%

* McCauley's survey included all mining affected areas including pits and ponds.

** An additional 53 acres of pits and ponds should be added to the above average. In addition, a number of locations were not included in the average if the area appeared totally revegetated.

Table 4

Volumes of Mine Waste Types

Area	CUBIC YARDS						
	Rock	Chat	Sand	Tailing	Stream Sediment	Total	%
Baxter Springs	60,138	1,325,117	64,387	78,496	1008	1,529,146	20
Galena (this survey)	25,943	139,554	-	-	492	165,989	2
Treece	148,230	3,481,117	431,203	215,175	758	4,276,483	56
Waco	10,407	66,178	78,559	68,524	-	223,668	3
Lawton	4356	22,103	-	-	-	26,459	-
Badger	52,078	47,438	5840	81	-	105,437	1
TOTAL	301,152	5,081,507	579,989	362,276	2,258	6,327,182	-
% this survey	5	80	9	6	-	100	-
Galena (previous survey)	508,536	735,639	-	-	34,396	1,278,571	17
GRAND TOTAL	809,688	5,817,146	579,989	362,276	36,654	7,605,733	100
PERCENTAGE	11	76	8	5	-	100	-

while chat accounted for 80% of the volume. When the previously studied Galena subsite volumes are added in, the rock percentage increases to 11% for the reasons previously explained. The vast majority of the surface mine waste (56%) is located near Treece with Baxter Springs and Galena being nearly equal at 20% and 19% respectively.

In 1983 McCauley estimated the size of a number of "chat" piles in the Cherokee County area. His measurements were only of individual large piles and in reality did include some rock piles in addition to chat. If one assumes a standard cone shape for most and a wedge shape for the others, the volume for 25 piles (where three dimensions were given) alone is 1,137,070 cubic yards as shown in Table 5. A further attempt to correlate volumes estimated in this study with McCauley's estimates yielded the last column in Table 5. As can be seen from the table, both estimates yield similar results.

In addition to estimating the volume and acreage of surface mine wastes, a modest attempt was made during the survey to estimate the volume of open mine shafts or subsidence areas as they were encountered. However, no attempt was made to locate all shafts, subsidence zones, or ponds as dense groundcover exists around and in many of the disturbed mine areas. This procedure was done for all subsites except the Galena area. Table 6 presents a summary of the preliminary estimates. This data indicates that the waste rock could easily be disposed of in the open mine shafts, subsidence zones and ponds. However, because the void locations do not necessarily coincide with the location of the waste rock piles, some trucking of material would be required.

In order to determine the chemical characteristics of the mine wastes, 27 samples were taken at most of the larger chat, sand, or tailing locations. Appendix D lists the

Table 5

Comparison of Volumes of Mine Waste

McCauley Number (Page)	Andes Number	McCauley Dimension (1983)	McCauley (1983) (yd^3)	Andes (1988) (yd^3)
3(182)	W1-S1/C	300' X 80'	69,600	59,361
1(182)	B5-R2	250' X 120' X 30'	16,667	28,394
1(183)	G1-C2	150' X 20'	4350	7,502
2(183)	G1-C4	150' X 250' X 20'	13,889	43,220*
5(183)	8A-C3	400' X 12.5'	19,400	18,969
10(184)	6D-C1	300' X 40'	34,920	33,880
12(184)	5D-C1	300' X 450' X 20'	50,000	39,115
14(184)	6A-C2	100' X 20'	1,940	3,323
18(184)	5ZA-C1	150' X 240' X 30'	20,000	25,937
24(185)	5A-C18	120' X 300' X 20'	13,333	8,678
25(185)	7B-C2	300' X 75'	65,475	75,972
27(185)	7A-C2	250' X 12.5'	7,578	46,390*
28(185)	7A-C1	125' X 270' X 12.5'	7,813	14,598
31(186)	2D-C5	100' X 200' X 20'	7,408	7,113
34(186)	3C-C5	350' X 25'	29,706	13,227**
44(187)	1H-C7	220' X 25'	11,737	3468**
45(187)	1H-C8	200' X 12.5'	4,850	6,291
47(187)	G6-C1	150' X 300' X 25'	20,833	33,799
48(187)	G8-C1	350' X 450' X 35	102,083	17,641**
7(188)	T2-C11	400' X 550' X 80'	325,926	279,101
15(189)	T4-S2/C	750' X 35'	190,313	244,415
2(191)	BS4-C1+S1	400' X 600' X 22.5'	100,000	47,431
			1,117,821	1,057,825
8(184)	G4-C1	25' X 150'	5,456	-
15(184)	6B-C1	30' X 180'	9,428	-
46(187)	---	20' X 150'	4,365	-
			1,137,070	

* The Andes estimates include more area than the one pile in McCauley's data.

** These piles have been significantly reduced in volume since the 1983 study as indicated by a comparison of the pile measurements.

Table 6

Volume of Located Subsidence Areas, Mine Shafts and Ponds*

Area	Subsidence Areas, Shafts & Ponds With Depth** (yd^3)	Ponds with Unknown Depth*** (acres)
Baxter Springs	601,923	7.02
Galena****	-	-
Treece	67,920	8.56
Waco	22,425	6.47
Lawton	-	-
Badger	16,295	.26
TOTAL	708,563	22.31

* No attempt was made to locate all abandoned mine shafts, subsidence zones, or ponds.

** For these areas the depth from ground surface to water level was estimated. No attempt was made to ascertain the depth of the hole below the water level.

*** For these areas the water level was essentially equal to the ground surface. No attempt was made to ascertain the depth of the pond and only acreage is estimated.

**** No shafts or ponds were located during this survey and the initial survey did not attempt to estimate this parameter.

actual sampling sites. Table 7 presents a summary of the distribution of samples by waste type and subsite. No samples were taken at the Badger, Waco or Lawton areas as the amount of surface mine waste located there did not appear to warrant sampling. A small hand shovel was utilized to take ten scoops of material at each site, yielding approximately eight pounds per sample. Ten randomly located points on each site were selected and the top four to six inches of material removed before the actual sample was taken. It was quite apparent during the sampling that segregation of materials occurs within each site. This would be expected as the ore changed composition and as the waste materials were deposited on the surface. Each sample was placed in double ziploc plastic bags and labeled before being sent by Federal Express to the AMAX R&D Laboratory in Golden, Colorado for analysis. Appendix E presents the analytical results.

Conclusions

From this study and the previous Galena subsite study it is estimated that at least 1,872 acres and 7,600,000 cubic yards of surface mine waste exist in the Cherokee County Superfund Site. Approximately 76% of the material is chat with waste rock making up 11%, although outside of the Galena Subsite waste rock only amounts to 5% of the volume. The vast majority of the surface mine waste (56%) is located near Treece with Baxter Springs and Galena volumes being nearly equal at 20% and 19%.

Correlation of the findings from these studies with those from McCauley's 1983 survey indicate a general agreement in affected acreages and substantiate estimated waste volumes.

Although only a preliminary study was conducted, data indicates that the waste rock fraction of the surface mine waste could easily be disposed of in the open mine shafts, subsidence zones, and ponds.

Table 7

Samples Taken

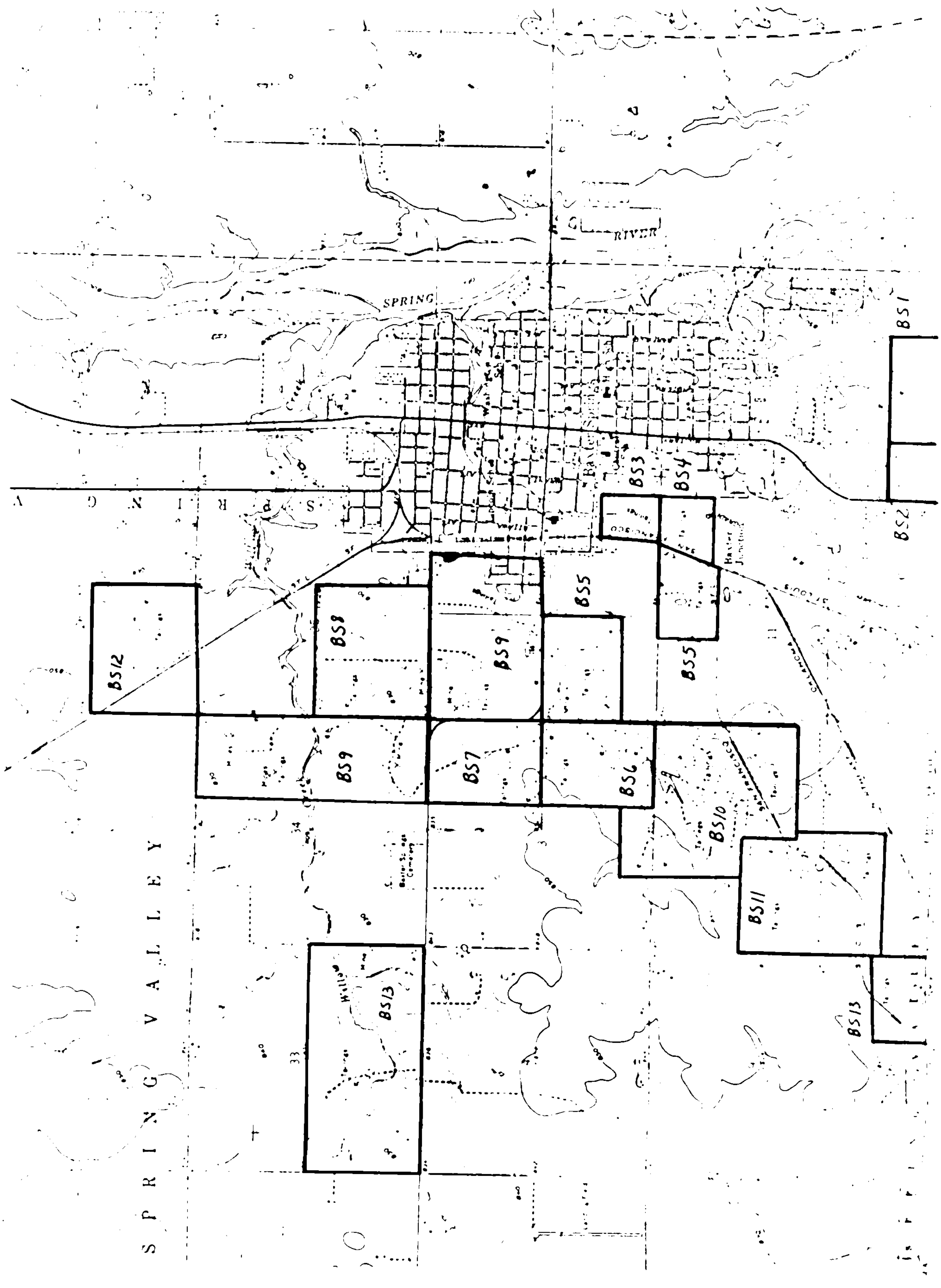
Area	Chat	Sand	Tailing	Total
Galena	10*	-	-	10
Baxter Springs	3	-	1	5**
Treece	8	1	3	12
TOTAL	21	1	4	27

* One sample in the Galena area was of chat being used as roadway gravel.

** One sample in the Baxter Springs area was a combination of chat, sand, and tailing.

Appendix A

BAXTER SPRINGS SUBSITE
AREA MAP




RI-34


19.8
29.0
354
15.1
2
16.2
56.3
3
38.1

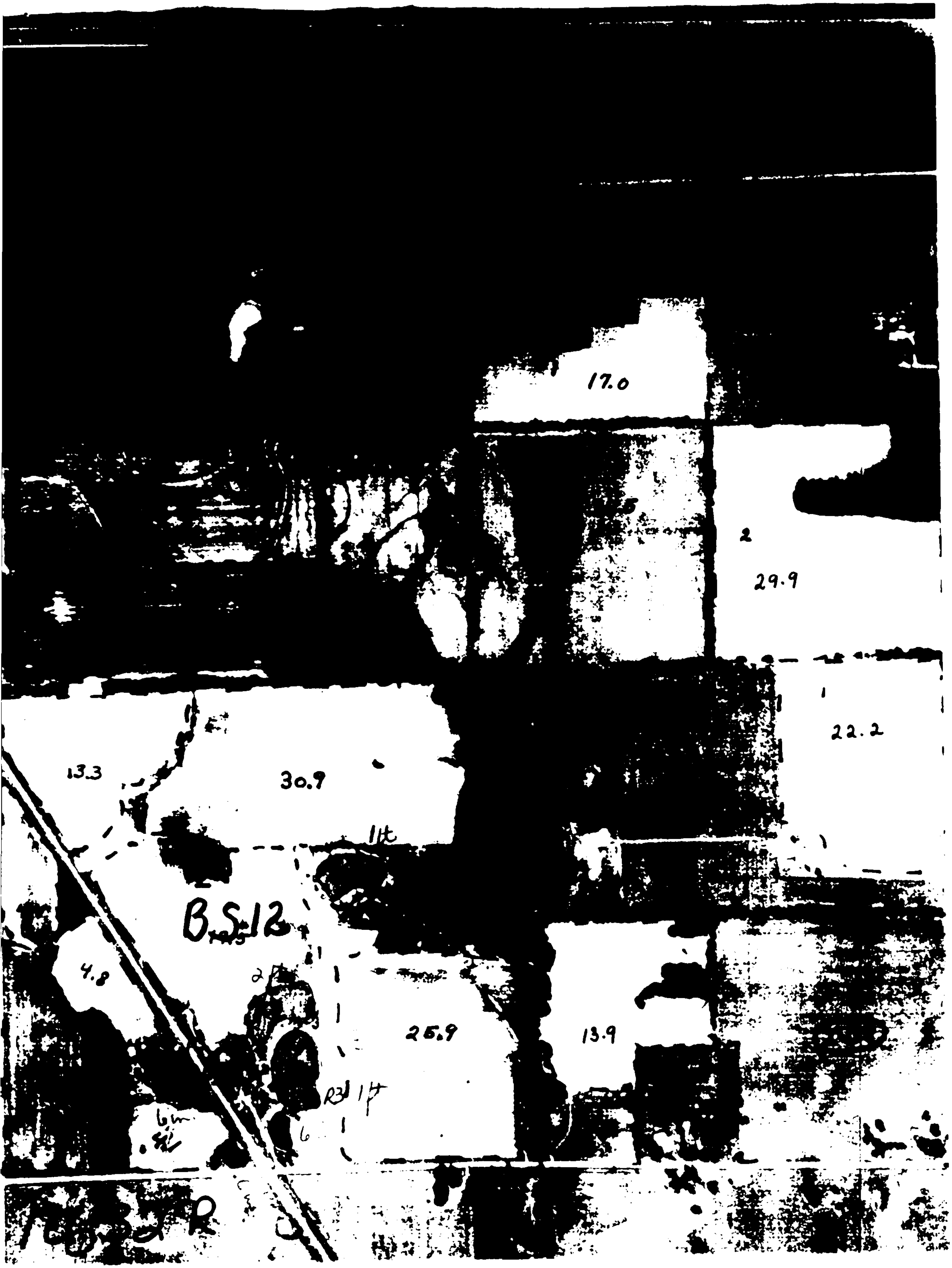
1
I-153
35.0
2
4.6
R


69.1
73.1
25.5
I-240
C3
R2
8ft
SSI

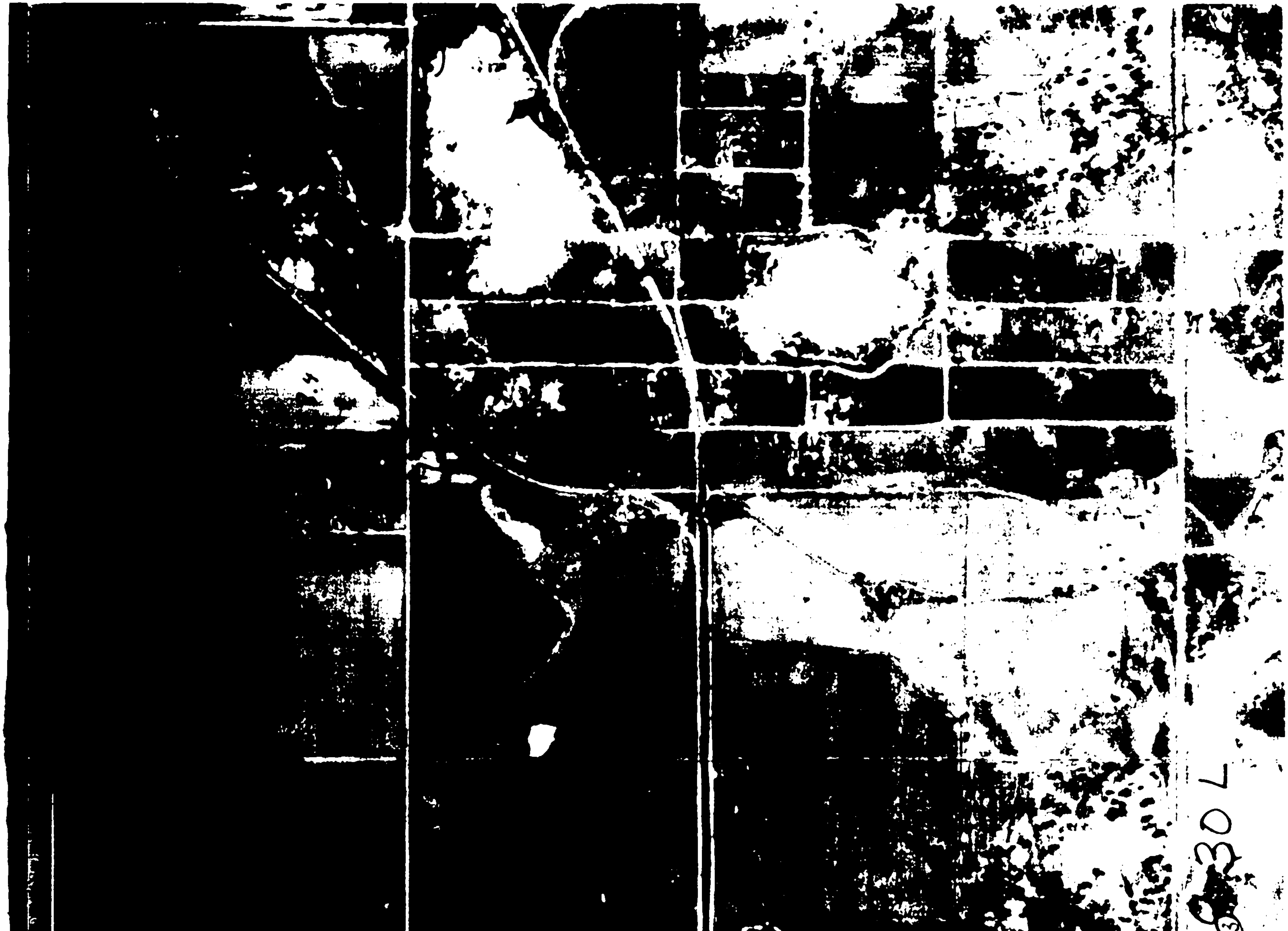
J-12

31.3
20.0
21.6
32.9
10ft
859
R1
0ft

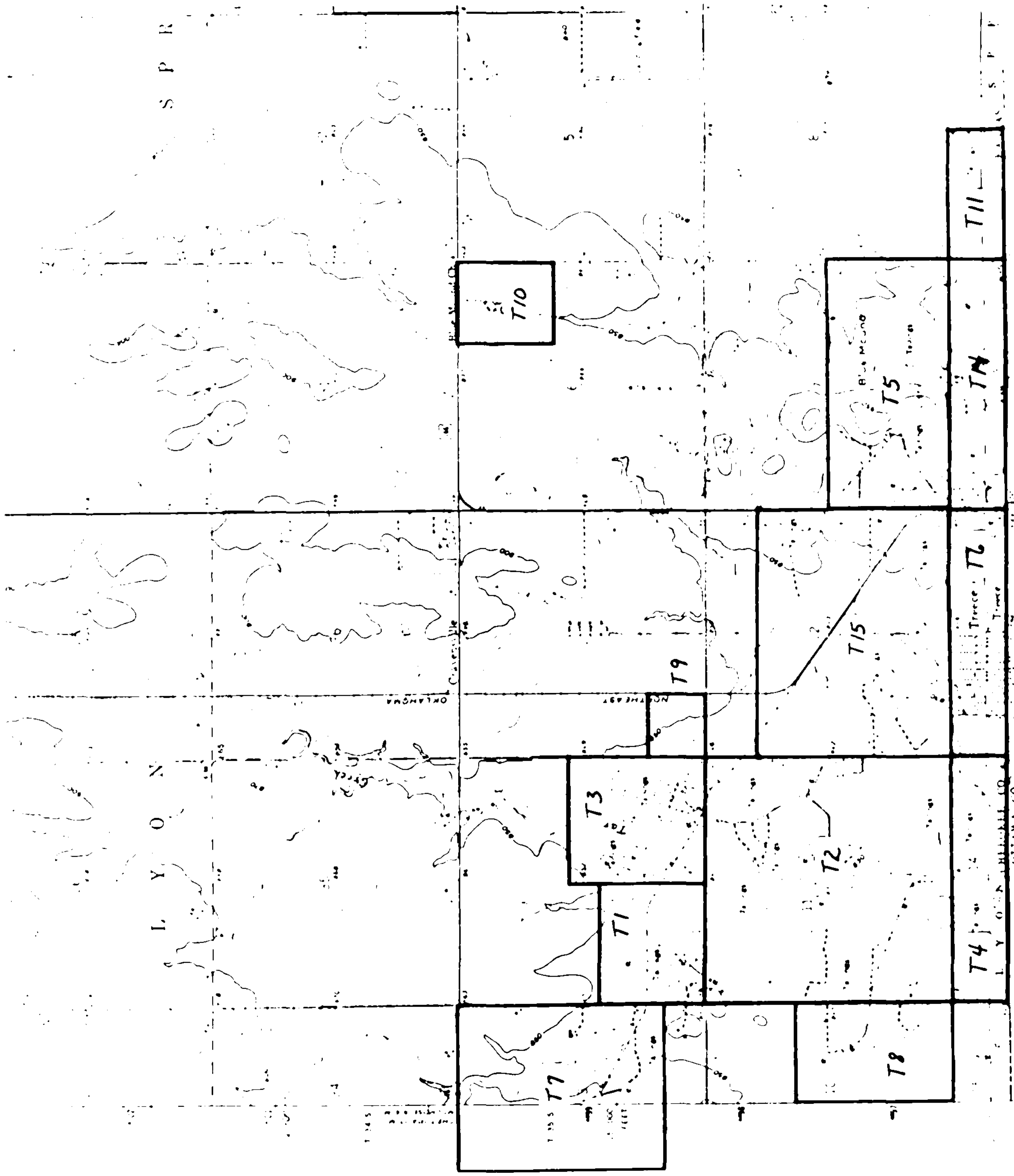
18.0
4.0
BS11
19.0
I-82
54.0
15.7
29.1
6.5


17.0
2
29.9
1
22.2
13.3
30.9
B.S. 12
4.8
25.9
13.9


12.8
4.7

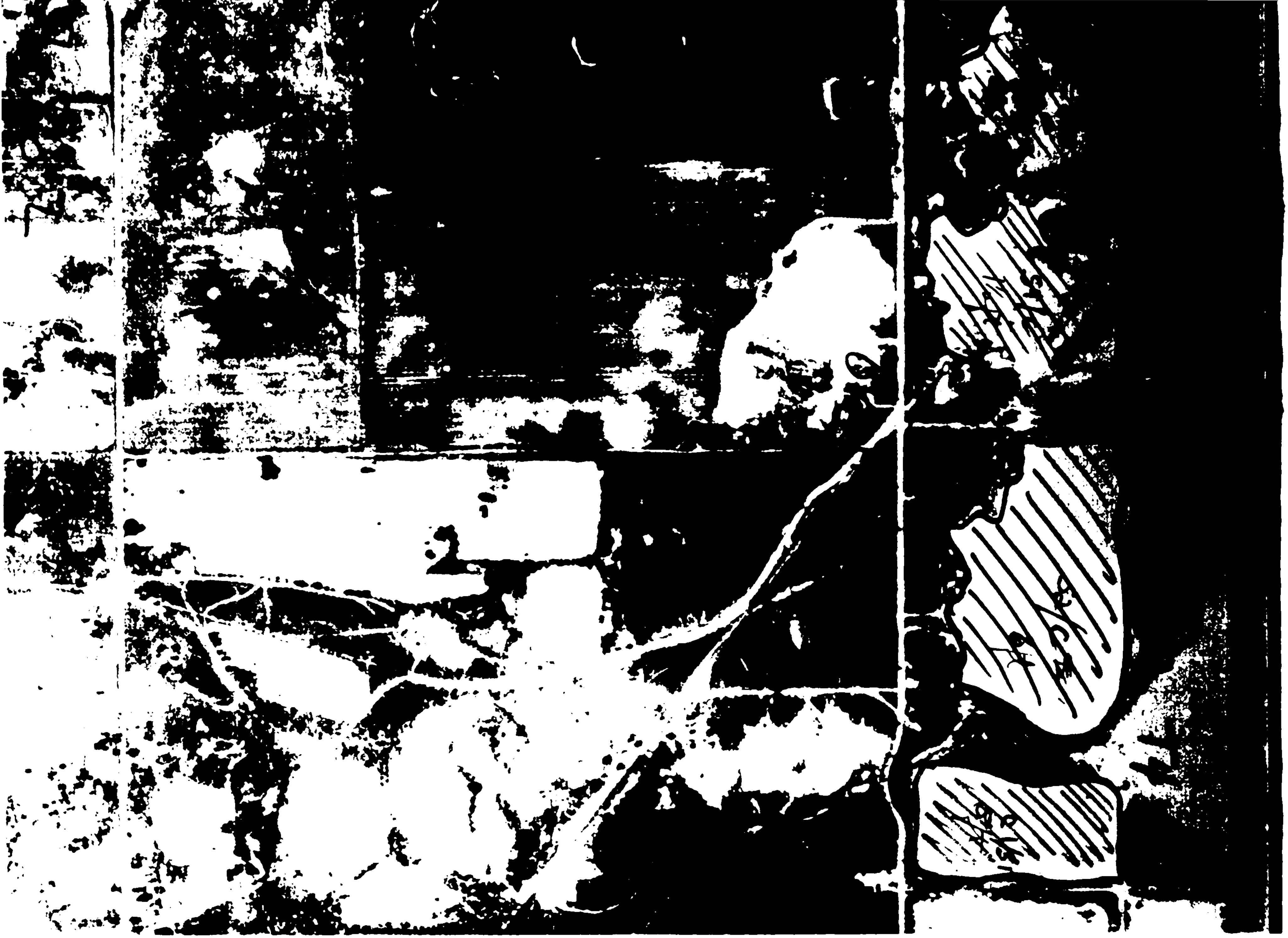

30L

TREECE SUBSITE
AREA MAP

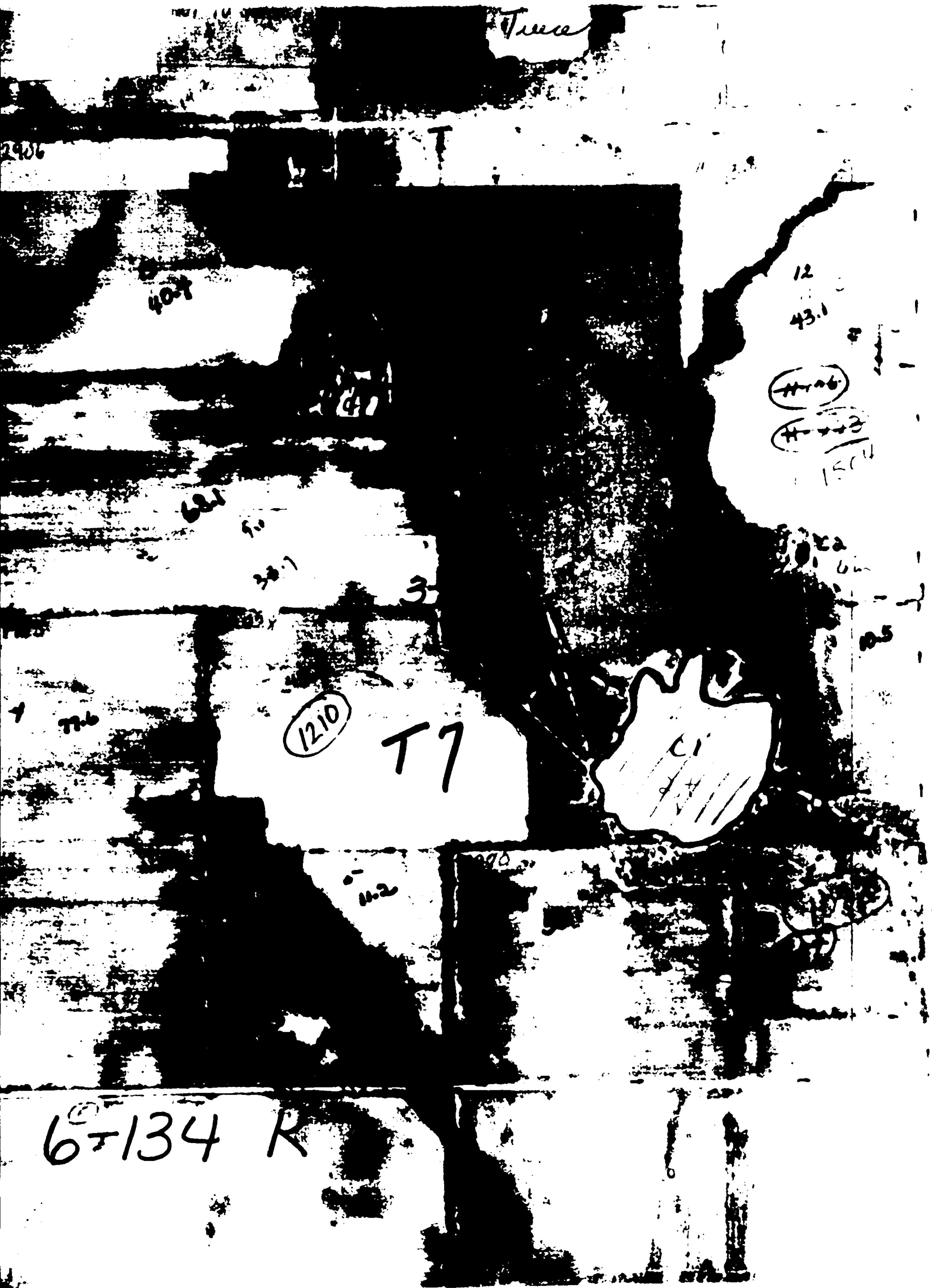



TREECE
6
144.3
H-106
7
34.1
7.1
28.5
14.1
2-35-23
13.4
86.8
T1
9.1
C4
C7
C2
C3
5
7-81L


36.2
C7
PS
C10
C11
R15
CB 3
R14
48.9
T B
C9




8.1
9.3
17.5
4.5
10.5
4.4
3.2
25.8
30.7
R3
C3
C1
C2
C1
20.6

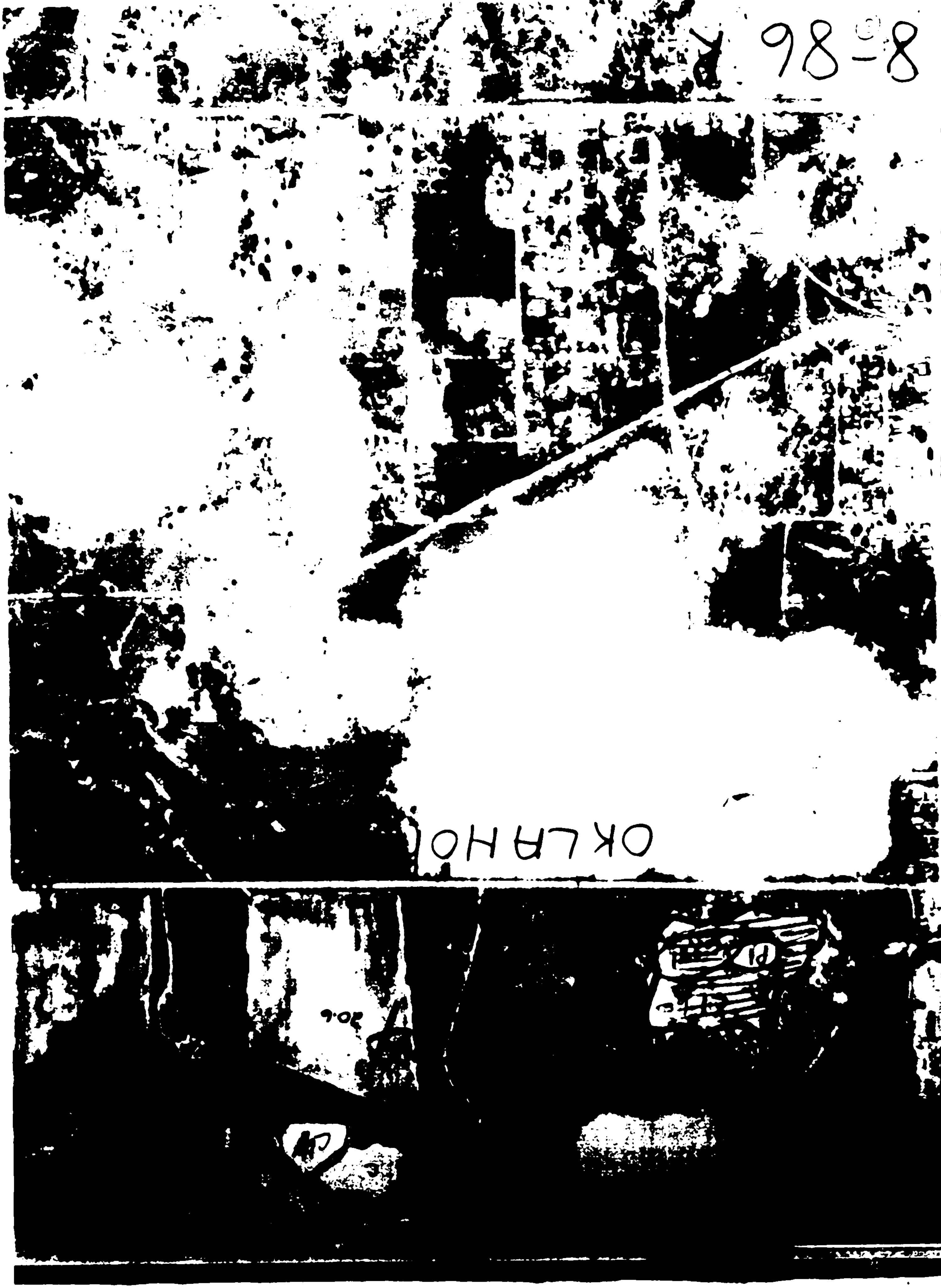


1210
T7
C1
12
43.1
6-134 R


113.8
8
9.6
T8
A
I-288
C
B

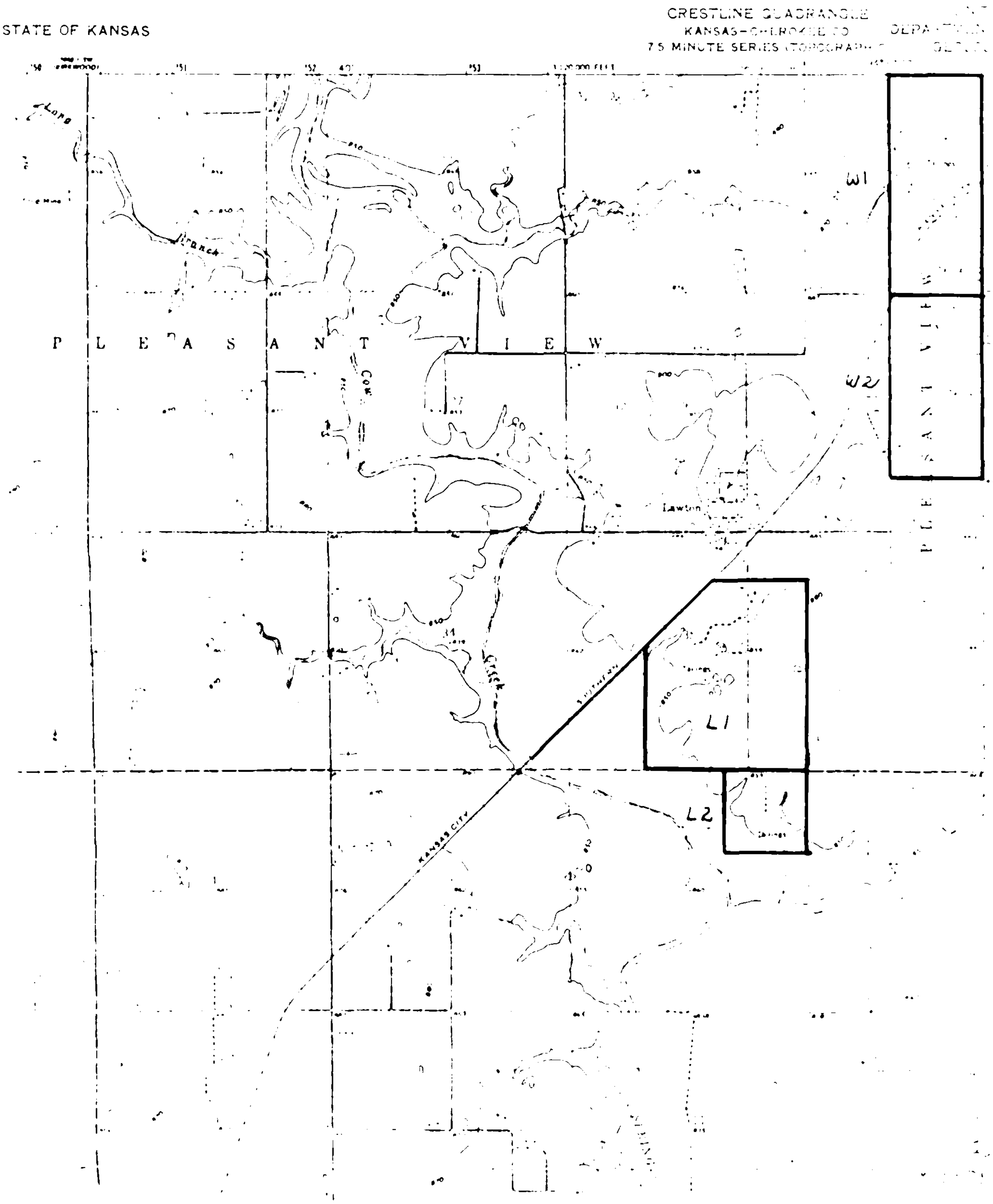
155.0
19.0
H-132
H-37
10.6
H-54
69.9
T9
33.6
R1
T-87

87
32.7
44.5
16.7
32.7
19
32.5
H-21
40.8
I-220
7.8
20
33.9
8 ⑤ 87 R


98-8

31.2
11.1
13.4
4.6
17.2
16.4
10.1
37.3
23.0
35-23
9.7
7
23.2
15
7.1
10
3.6
T4
T3
C4

WACO AND LAWTON SUBSITES
AREA MAP

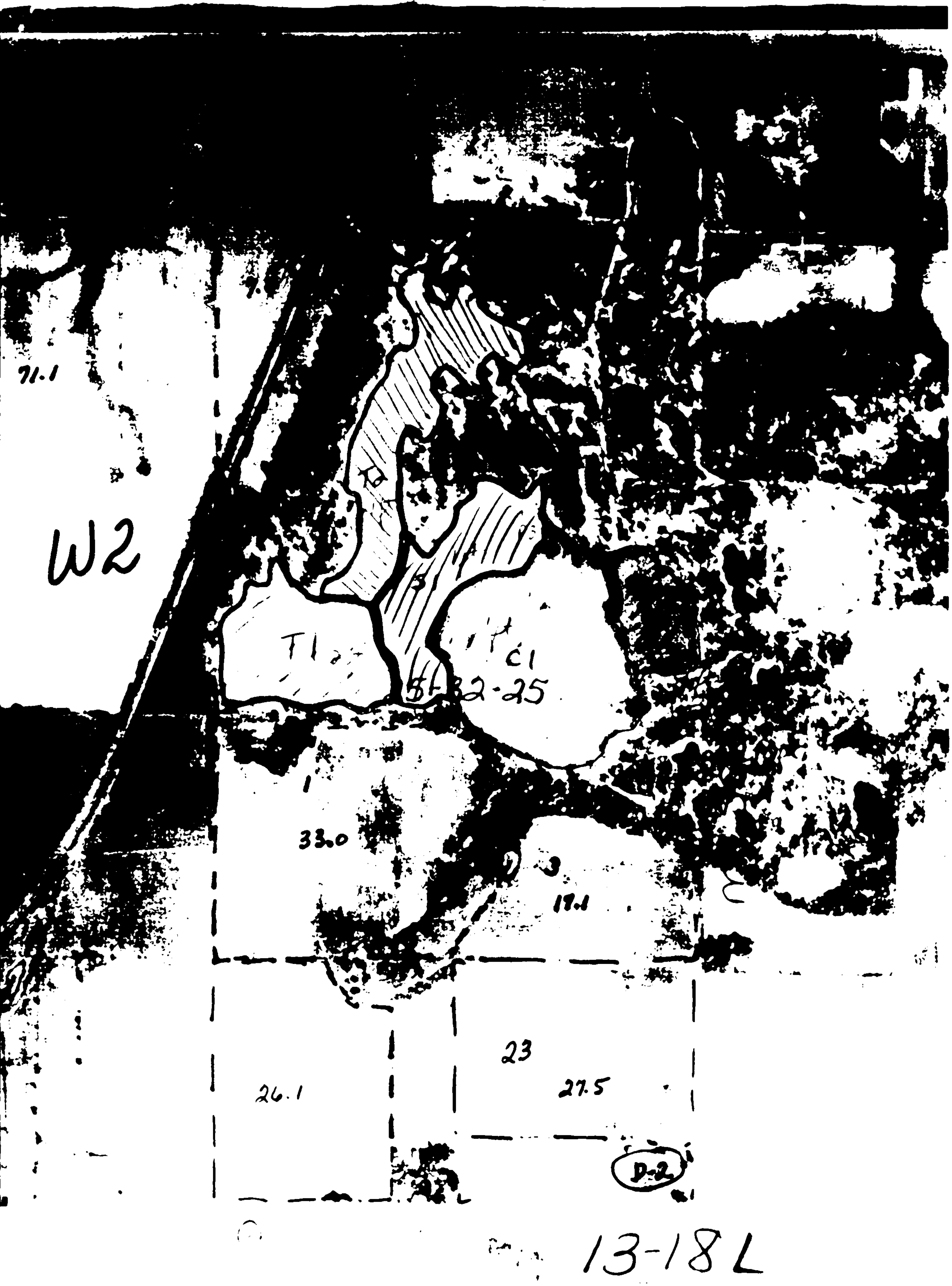


LAWTON
19.6
13
21.2
12
61.6
D-1
14
15.
15
15.1
3.0
31.2
11.2
4
13.0
16
L1
82.0
114.7
7
9.9
8
14.1
C1

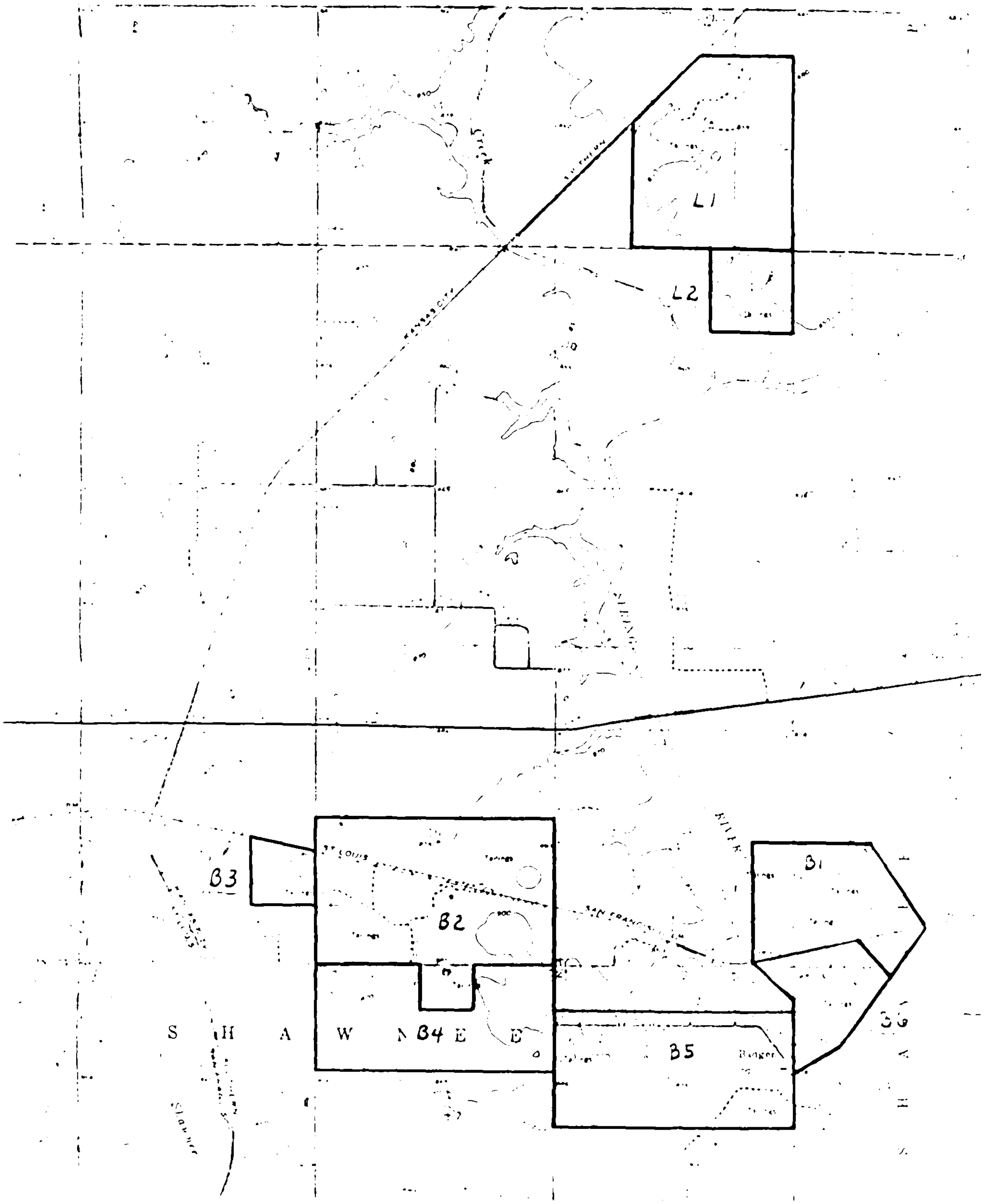
L2
14
27.5
15
23.0
16
22.4
17
14.2
13
D-2
158.5
2-33-25
3
61.7
G-131

M-5

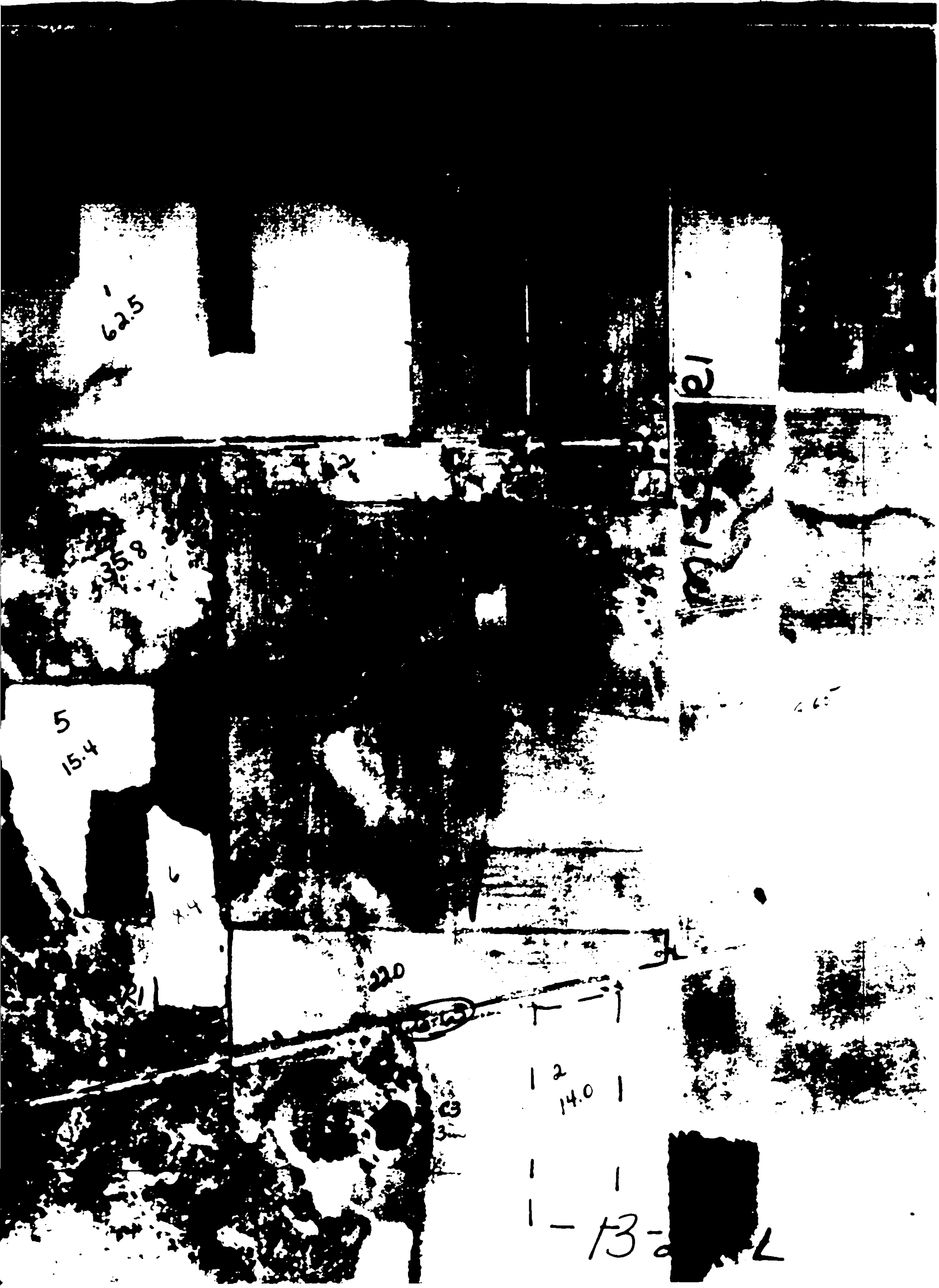
WACO


71.1
W2
T1
C1
32-25
33.0
19.1
23
26.1
27.5
D-2
13-18L

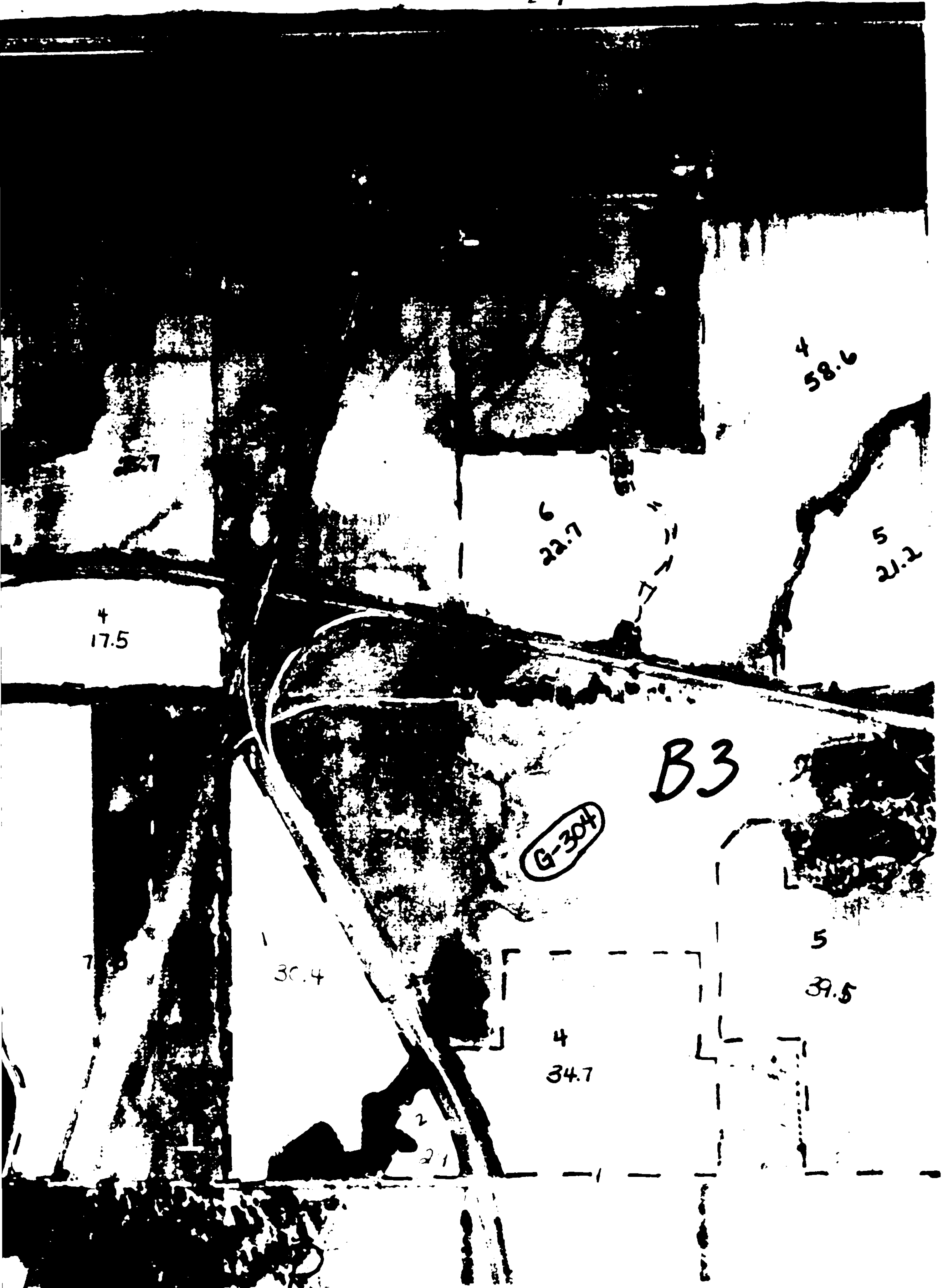
BADGER AND LAWTON SUBSITES
AREA MAP

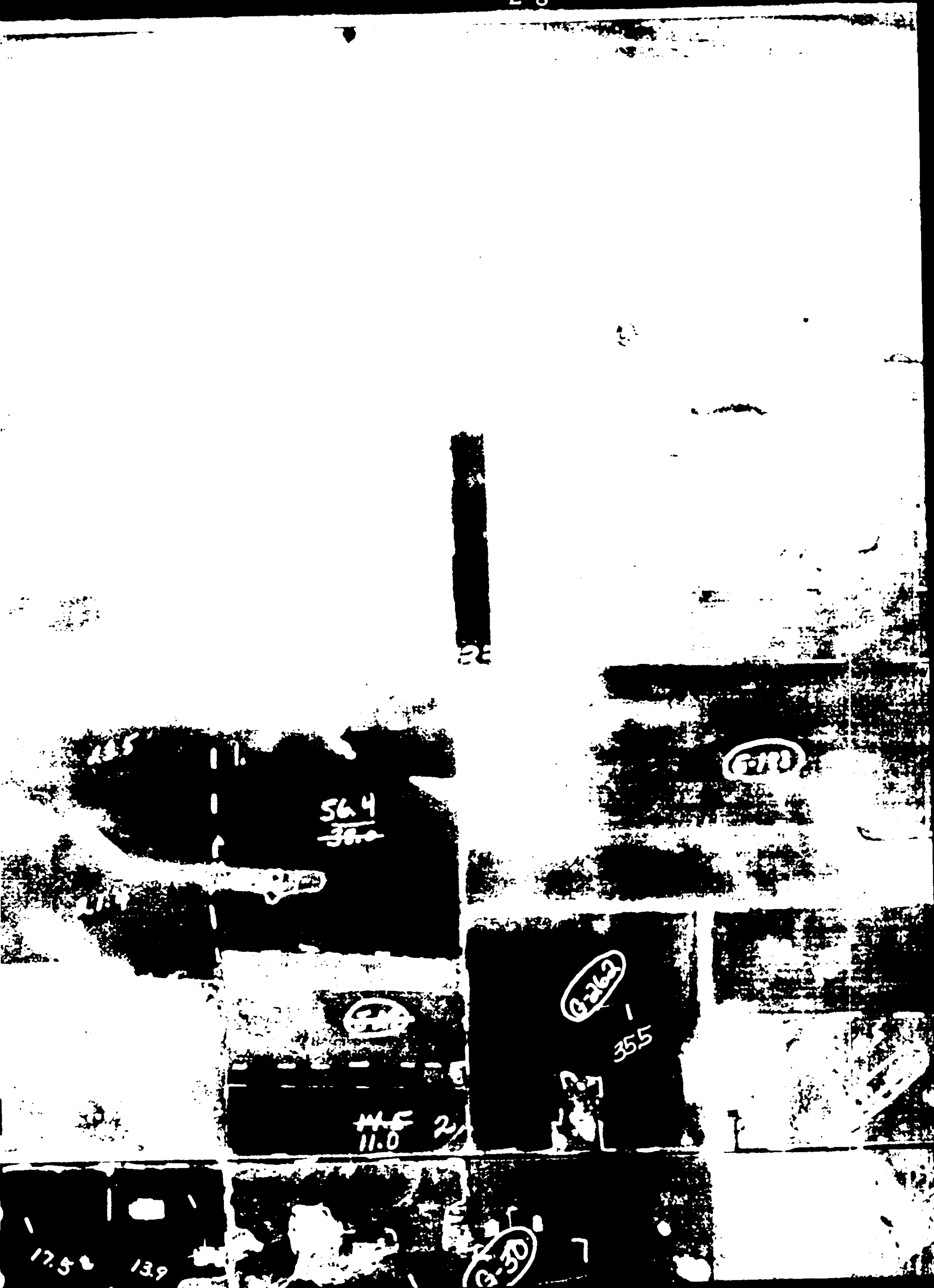


M- M-7 BADGER




1
99.6
2
NA
18.0
B2
15
6.9
G-306
not accessible or visible
37.2
P1
10 ft
8
11.1
2
52.2
R6
3 ft
R5
3 ft
R7
P5
20 ft
75 R

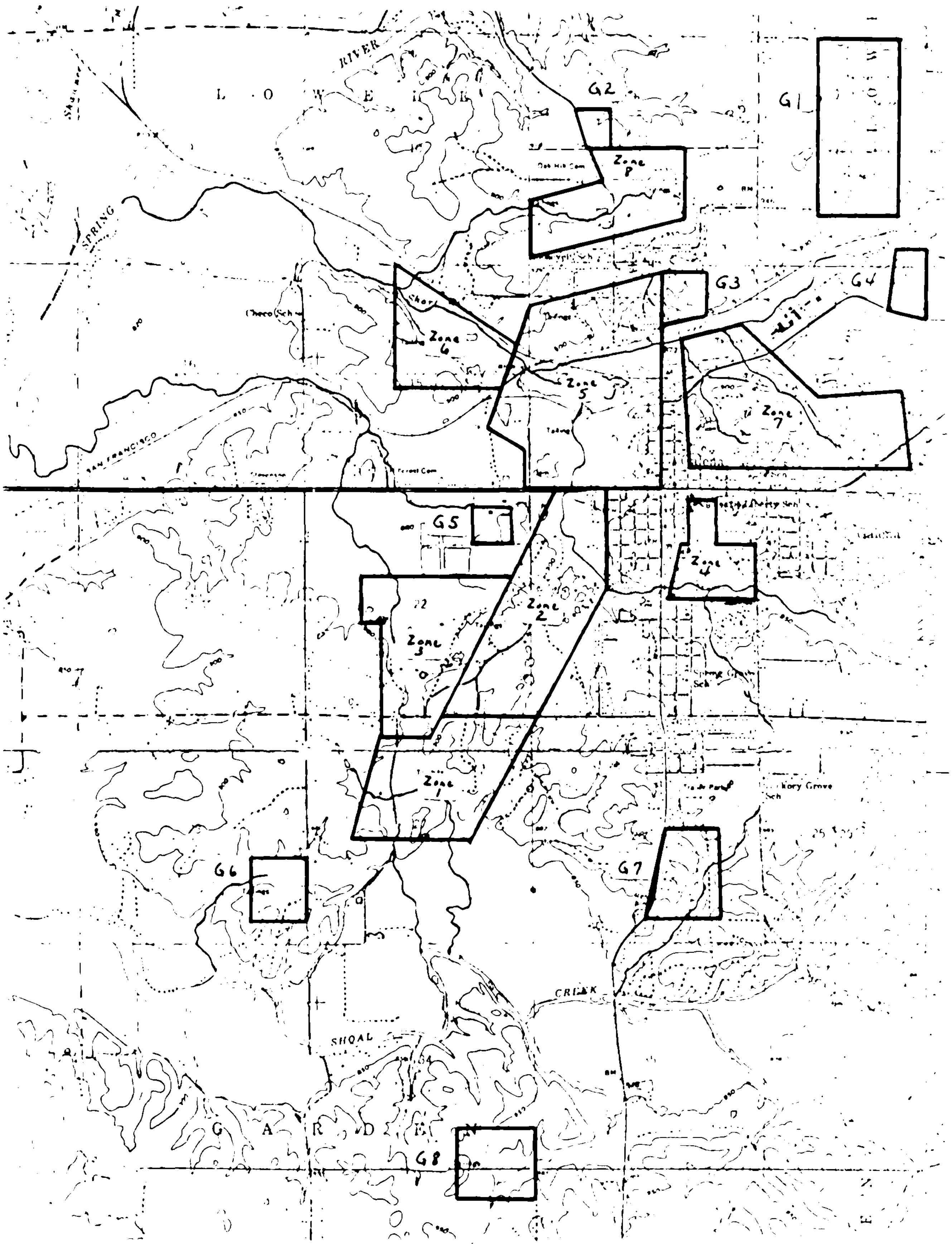

4
58.6
6
22.7
5
21.2
4
17.5
B3
G-304
5
39.5
1
30.4
4
34.7
2
21


56.4
G-262
355
11.0
17.5
13.9
G-30


G-231
G-209
G-259
B5
R4
3/4 A3
23
33-25
G-159
13
10.3
23.8
38.6
2
9.7
3
32.8
11.8
5
21.8
4.7
10.2
17.1
5.7


36

GALENA SUBSITE
AREA MAP

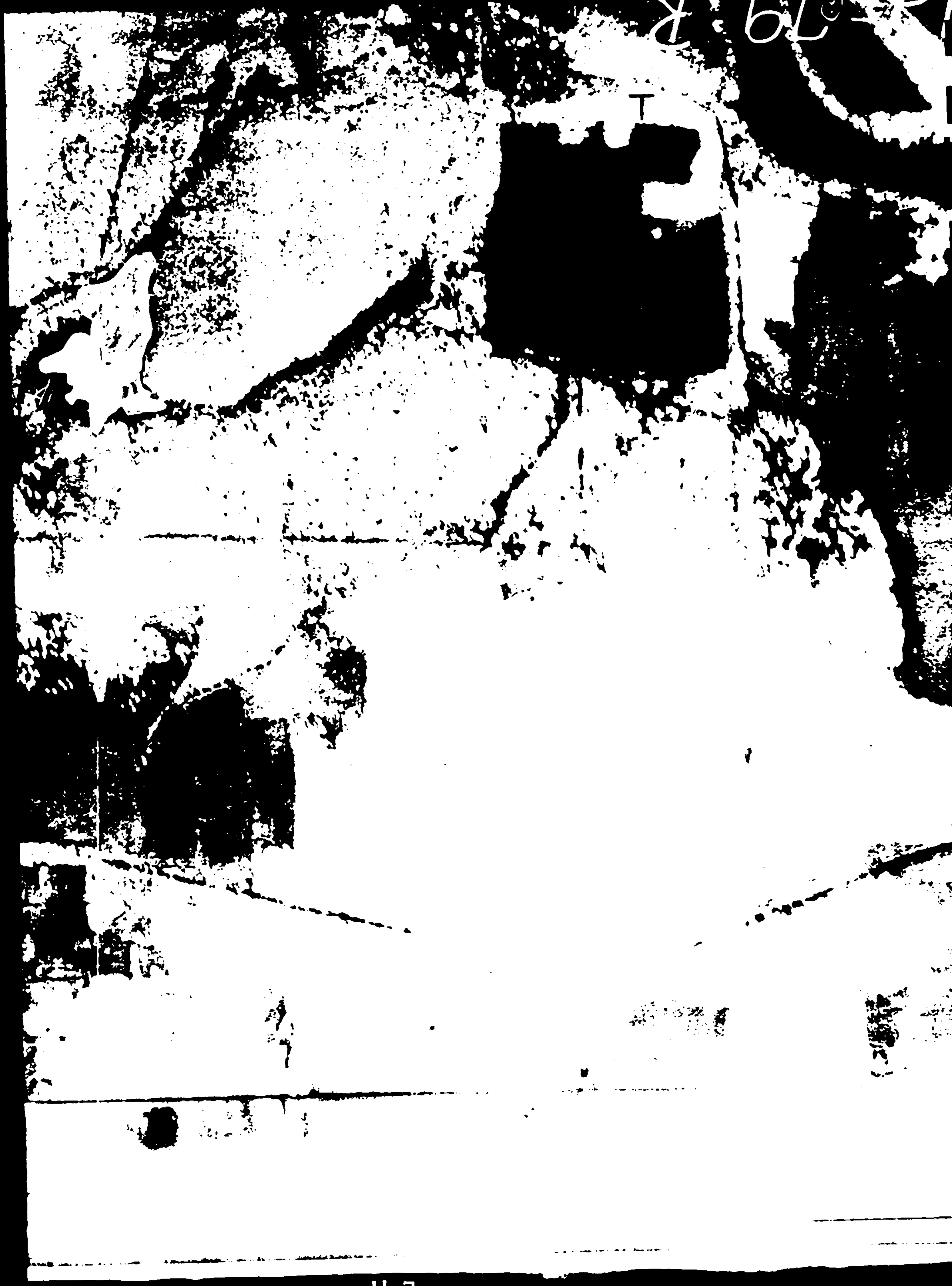


M-10 Galena - Supplemental


J-29
J-46
L

M-10


active
22-34-25



M-11


G8
C1

Appendix B

		Depth	Acres	yd^3
T1	C1	1 ft.	2.06	3,323
*	C2	20 ft.	8.91	287,490
	C3	6 in.	11.67	9,414
	S1	2 ft.	.89	2,872
*	T1	1 ft.	3.14	5,066
T3	C4	1 ft.	17.67	28,507
	C5	3 in.	1.67	674
	C6	6 in.	1.58	1275
*	C7	8 ft.	56.28	726,372
	R1	20 ft.	.34	10,970
	R2	8 ft.	.05	645
	T2	6 in.	.68	549
	P1	20 ft.	.05	1,613
	P2	30 ft.	.76	36,783
	P3	20 ft.	.09	2,904
	P4	--	.92	--
T2	C1	6 in.	12.63	10,188
	C2	3 ft.	.18	871
	C3	3 in.	8.89	3,586
	C4/S	6 in.	6.19	4,993
	C5	1 ft.	10.13	16,343
	C6	6 in.	6.86	5,534
*	C7	8 ft.	22.85	294,911
	C8	6 in.	3.39	2,735
*	C9	4 ft.	40.20	259,419
	C10	2 ft.	21.48	69,307
*	C11	25 ft.	6.92	279,101
	C12	1 ft.	1.60	2,581
	C13	3 ft.	.68	3,291
	C14	2 ft.	5.27	17,004
	R1	10 ft.	.21	3,388
	R2	12 ft.	.14	2,710
	R3	15 ft.	.21	5,082
	R4	10 ft.	.10	1,613
	R5	1 ft.	.15	242
	R6	8 ft.	.27	3,485
	R7	15 ft.	.28	6,776
	R8	15 ft.	.23	5,566
	R9	10 ft.	.24	3,872
	R10	8 ft.	.30	3,872
	R11	3 ft.	.23	1,113
	R12	8 ft.	.11	1,420
	R13	4 ft.	.53	3,420
	R14	5 ft.	.16	1,291
	R15	2 ft.	.18	581
	S1/C	6 in.	6.40	5,163

* Indicates a pile or location which was sampled

		Depth	Acres	yd^3
	T1/S1	6 in.	3.45	2,783
	T2/S2	6 in.	1.23	992
*	T3	3 ft.	31.31	151,537
	T4	6 in.	1.17	944
	T5	6 in.	.48	387
	T6	3 ft.	.52	2,517
	T7	6 in.	1.62	1,307
	P1	-	.14	-
	P2	30 ft.	.45	21,780
	P3	-	.91	-
	P4	-	.76	-
	P5	20 ft.	.09	2,904
	P6	-	.59	-
	P7	-	.66	-
	P8	-	.41	-
	P9	20 ft.	.06	1,936
	P10	-	.98	-
T4 *	C1/S1	8 ft.	15.56	200,823
	C2/S	6 in.	13.58	10,954
	S1/C	1-1/2 ft.	18.91	45,761
*	S2/C	6 ft.	25.25	244,415
	R1	5 ft.	.63	5,082
	R2	4 ft.	.10	645
	R3	5 ft.	.32	2,581
	R4	6 ft.	.20	1,936
	SS1	6 in.	.94	758
	T1	1 ft.	2.54	4,098
T5	C1	3 ft.	11.41	55,223
*	C2	25 ft.	10.28	414,618
	C3	5 ft.	14.24	114,867
	C4	3 ft.	6.90	33,395
	C5	6 in.	.95	766
	C6	6 in.	8.29	6,687
	C7	1 ft.	9.14	14,746
	C8	1 ft.	4.48	7,228
	R1	5 ft.	.56	4,517
	R2	5 ft.	.19	1,533
	T1	6 in.	.79	637
	P1	-	.76	-
	R3	5 ft.	.17	1,371
	R4/C	15 ft.	1.19	28,797
T6	C1	2 ft.	1.69	5,453
	C2	2 ft.	8.76	28,265
	C3	1 ft.	.45	726
	R1	15 ft.	.59	14,278
	R2	4 ft.	.23	1,484

* Indicates a pile or location which was sampled

		Depth	Acres	yd^3
	R3	10 ft.	.30	4,840
	R4	10 ft.	.32	5,163
	S1/C	3 in.	1.18	476
	S2	3 ft.	5.03	24,345
	S3	3 ft.	8.83	42,736
	S4	2 ft.	1.97	6,356
	S5	2 ft.	1.40	4,517
	S6/C	2 ft.	8.80	28,394
	T1	6 in.	.97	782
	T2	6 in.	1.67	1,347
T7	C1	2 ft.	17.58	56,724
	C2	6 in.	.16	129
	C3	6 in.	5.10	4,114
	P1	-	.67	-
T8	C1	6 in.	9.84	7,937
	C2	3 in.	3.14	1,266
	R1	10 ft.	.28	4,517
T9	R1	8 ft.	.16	2,065
T10	C1	3 in.	.86	347
T11	C1	2 ft.	2.70	8,712
	R1	5 ft.	.23	1,855
	R2	5 ft.	.19	1,533
T14	C1	6 in.	11.50	9,276
	C2	6 in.	.73	589
	C3	3 ft.	.30	1,452
	P1	-	1.01	-
T15	C1	1 ft.	1.29	2,081
	C2	6 in.	2.92	2,355
	C3	3 in.	6.70	2,702
*	C4	15 ft.	17.06	412,843
	C5	3 ft.	2.10	10,164
	C6	2 ft.	8.52	27,491
	C7	6 in.	.70	565
	C8	9 in.	9.67	11,700
	R1	8 ft.	.13	1,678
	R2	10 ft.	.17	2,743
	R3	15 ft.	.23	5,566
	S1	2 ft.	.83	2,678
	S2/C	3 ft.	3.06	14,810
	S3	2 ft.	2.69	8,680
	T1	1 ft.	4.36	7,034
	T2	6 in.	2.90	2,339
	T3	9 in.	6.08	7,357
*	T4	1 ft.	10.88	17,553

* Indicates a pile or location which was sampled

		Depth	Acres	yd^3
	T5	1 ft.	4.79	7,728
	T6	6 in.	.27	218
	P1	-	.75	-
B1	C1	3 ft.	.18	871
	C2	6 ft.	.28	2,710
	C3	3 in.	1.04	419
	R1	5 ft.	.12	968
B2	C1	1 ft.	2.41	3,888
	C2/S	3 in.	3.67	1,480
	C3	6 in.	3.71	2,993
	C4	6 in.	6.10	4,921
	C5	9 in.	1.03	1,246
	R1	8 ft.	.43	5,550
	R2	5 ft.	.18	1,452
	R3	6 ft.	.31	3,001
	R4	6 ft.	.08	774
	R5	3 ft.	.24	1,162
	R6	3 ft.	1.13	5,469
	R7	3 ft.	.10	484
	S1	1 ft.	3.62	5,840
	T1	6 in.	.10	81
	P1	10 ft.	.41	6,615
	P2	20 ft.	.07	2,259
	P3	-	.10	-
	P4	-	.16	-
	P5	20 ft.	.23	7,421
B3	C1	6 in.	1.42	1,145
	C2	1 ft.	2.89	4,662
B4	C1	6 in.	.83	670
	C2	3 in.	.83	335
	R1	5 ft.	.16	1,291
B5	C1	6 in.	.29	234
	R1	8 ft.	.21	2,710
	R2	10 ft.	1.76	28,394
	R3	3 ft.	.07	339
	R4	3 ft.	.10	484
B6	C1	4 ft.	1.80	11,616
	C2	6 in.	11.90	9,599
	C3	3 in.	1.61	649
L1	C1	3 ft.	.21	1,016
	C2	1 ft.	6.30	10,164
	C3	1 ft.	1.51	2,436

		Depth	Acres	yd^3
	C4	1 ft.	.65	1,049
	C5	1 ft.	2.08	3,356
L2	C1	1 ft.	2.53	4,082
	R1	10 ft.	.27	4,356
W1	C1	6 in.	12.60	10,164
	C2	6 in.	.37	298
	C3	6 in.	4.76	3,840
	C4	3 in.	9.62	3,880
	R1	10 ft.	.15	2,420
	R2	10 ft.	.20	3,227
	R3	8 ft.	.13	1,678
	S1/C	1-1/2 ft.	24.53	59,361
	T1	6 in.	.95	766
	T2	6 in.	1.08	871
	P1	-	2.84	-
	P2	-	2.02	-
	P3	10 ft.	.73	11,777
	P4	10 ft.	.41	6,615
	R4	8 ft.	.08	1,033
W2	C1	1 ft.	21.97	35,444
	C2	1 ft.	.67	1,081
	C3	1 ft.	1.85	2,985
	C4	6 in.	2.80	2,259
	C5	6 in.	.79	637
	C6	6 in.	6.23	5,025
	C7	6 in.	.70	565
	R1	6 ft.	.12	1,162
	R2	5 ft.	.11	887
	S1	1 ft.	11.90	19,198
	T1	2 ft.	12.75	41,139
	T2	1 ft.	15.96	25,748
	P1	10 ft.	.25	4,033
	P2	-	.08	-
	P3	-	.11	-
	P4	-	.76	-
	P5	-	.49	-
	P6	-	.17	-
G1	C1/R1	3 ft.	1.44	6,969
	C2	5 ft.	.93	7,502
	C3	2 ft.	.56	1,807
	C4	3 ft.	8.93	43,220
	R1	2 ft.	.89	2,872
G2	C1	6 in.	1.05	847
	R1	1 ft.	.50	807
	C2	1 ft.	1.03	1,662
G3	C1	5 ft.	.77	6,211
	R1	1 ft.	.58	936

		Depth	Acres	yd^3
G4	C1	2 ft.	1.68	5,421
	R1	1 ft.	1.84	2,968
G5*	C1	2 ft.	3.55	11,454
	R1	3 in.	1.16	468
G6*	C1	5 ft.	4.19	33,799
	R1	1 ft.	2.57	4,146
	SS1	6 in.	.61	492
G7	C1	9 in.	.33	399
	C2	3 in.	.74	298
	C3	1 ft.	.50	807
	C4	2 ft.	.47	1,517
	R1	3 ft.	.04	194
	R2	8 ft.	1.05	13,552
G8	C1	1-1/2 ft.	7.29	17,641
BS12	C1	6 in.	.48	387
	C2	1 ft.	1.59	2,565
	C3	2 ft.	1.80	5,808
	C4	2 ft.	2.10	6,776
	R1	6 in.	.26	210
	R2	6 in.	1.37	1,105
	P1	-	.30	-
	P2	-	.06	-
	P3	-	.10	-
BS13	C1	6 in.	3.17	2,557
	T1	5 ft.	3.97	32,024
	P1	-	1.60	-
BS9	C1	1 ft.	3.87	6,243
	R1	10 ft.	.28	4,517
	R2	10 ft.	.54	8,712
	R3	10 ft.	.45	7,260
	R4	10 ft.	.14	2,259
BS8*	C1	3 ft.	20.08	97,185
	C2	5 ft.	.39	3,146
	C3	3 ft.	.25	1,210
	C4	3 in.	1.35	544
	R1	10 ft.	.34	5,485
	R2	8 ft.	.04	516
	R3	4 ft.	.28	1,807
	T1	6 in.	.38	307
	T2	6 in.	.67	540

* Indicates a pile or location which was sampled

		Depth	Acres	yd^3
BS8	Pond 1	-	2.06	-
BS9	C1	6 in.	2.46	1,984
	C3	6 in.	1.30	1,049
	C4	1 ft.	4.67	7,534
	C5	6 in.	.68	549
	C6	3 in.	.70	282
	C7	3 in.	1.14	460
	R1	6 in.	.16	129
	R2/C2	6 in.	.60	484
	R3	12 ft.	.30	5,808
	R4	8 ft.	.11	1,420
	R5	3 ft.	.07	339
	T1	6 in.	.15	121
	T2	6 in.	.49	395
	P1	-	.32	-
	P2	-	.07	-
	P3	-	.25	-
	P4	-	.06	-
	P5	-	.04	-
	R6	1 ft.	.11	177
BS5	C1	6 in.	28.60	23,070
BS3	C1	1 ft.	10.86	17,520
BS7	C1	6 in.	5.31	4,283
	C2	3 ft.	1.36	6,582
BS6	C1	2 ft.	.35	1,129
	C2	6 in.	.40	323
	C3	6 in.	.63	508
	C4/R4	3 in.	2.34	944
	C5/R5	6 in.	6.72	5,421
	R1	6 in.	.24	194
	R2	8 ft.	.21	2,710
	R3	8 ft.	.25	3,227
BS10	C1	6 in.	1.57	1,266
	C2	3 ft.	50.36	243,737
*	C3	30 ft.	12.97	627,735
	C4	3 ft.	18.41	89,103
	C5	3 ft.	1.06	5,130
	R1	1 ft.	.04	65
	S1	4 ft.	5.24	33,815
*	T1	1 ft.	6.75	10,890
	T2	2 ft.	3.79	12,229
	T3	1 ft.	3.76	6,066
	T4	1 ft.	2.08	3,356

* Indicates a pile or location which was sampled

		Depth	Acres	yd^3
	T5	1 ft.	1.00	1,613
	T6	1 ft.	.10	161
	P1	-	1.17	-
	P2	-	2.66	-
	P3	-	.06	-
BS 11	C1	6 in.	4.43	3,573
	C2	6 in.	7.92	6,389
	C3	2 ft.	9.59	30,943
	C4	1 ft.	19.24	31,040
	C5	9 in.	2.01	2,432
	C6	6 in.	1.19	960
	C7	2 ft.	.16	516
	C8	6 in.	1.48	1,194
	R1	3 ft.	.52	2,517
	R2	2 ft.	.29	936
	R3	2 ft.	.20	645
	R4	10 ft.	.25	4,033
	R5	5 ft.	.31	2,501
	T1	6 in.	.26	210
	T2	6 in.	.44	355
	T3	1 ft.	1.61	2,597
	T4	6 in.	1.43	1,154
	T5	6 in.	1.63	1,315
	SS1	3 in.	1.01	407
	SS2	3 in.	1.49	601
	P1	-	.11	-
	P2	-	.22	-
	P3	50 ft.	5.95	479,957
	P4	50 ft.	.90	72,599
BS 4*	C1	5 ft.	2.09	16,859
	C2	2 ft.	.50	1,613
*	S1	5 ft.	3.79	30,572
*	T1	1 ft.	3.20	5,163
BS 5	C1	6 in.	10.09	8,139
	C2	6 in.	2.15	1,734
	C3	5 ft.	.20	1,613
	R1	5 ft.	.04	323
	R2	5 ft.	.06	484
	P1	30 ft.	.17	8,228
	P2	30 ft.	.13	6,292
BS 1	C1	3 in.	2.92	1,178
	C2	3 in.	1.05	423
	R1	1 ft.	.12	194

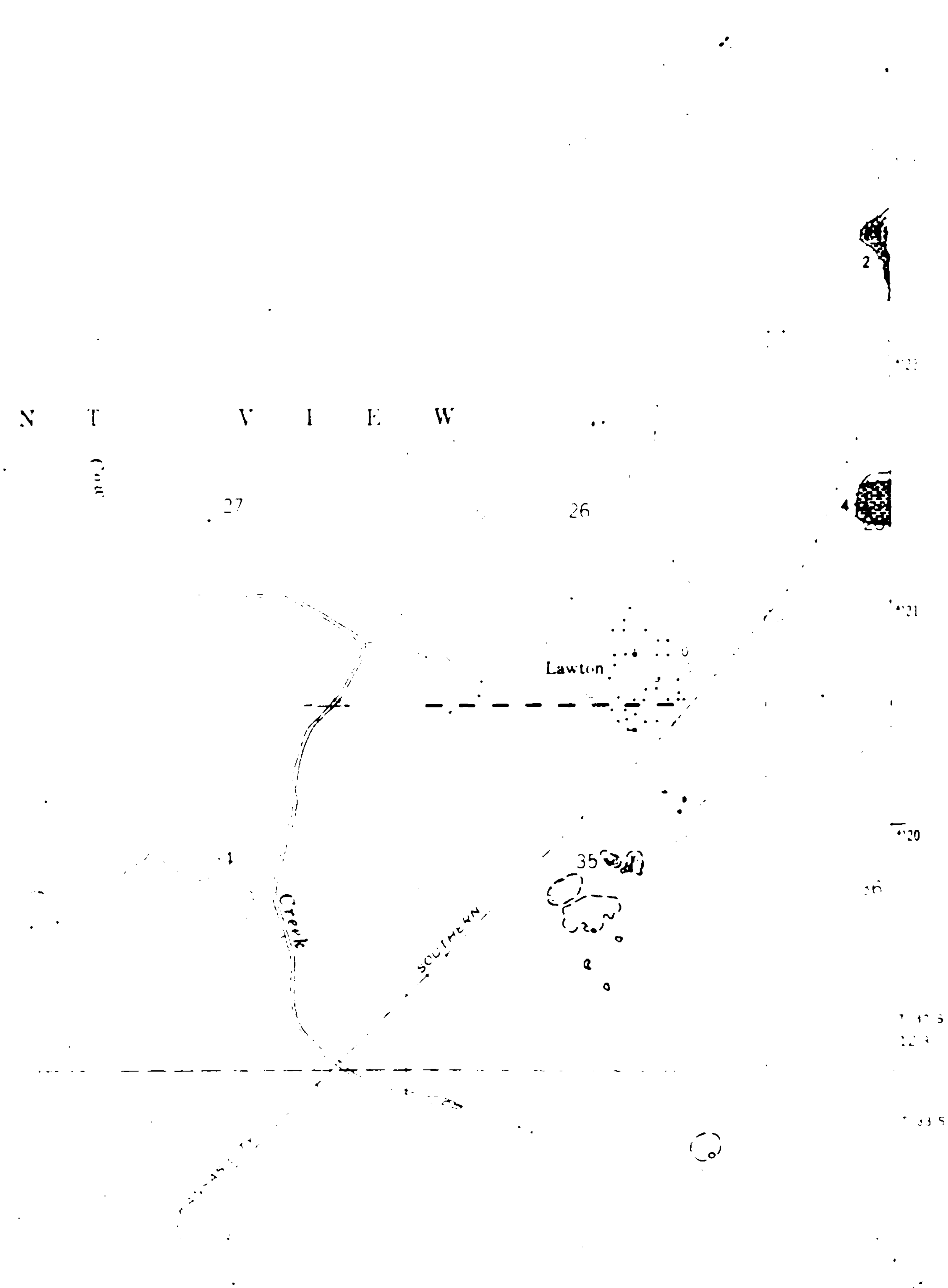
* Indicates a pile or location which was sampled

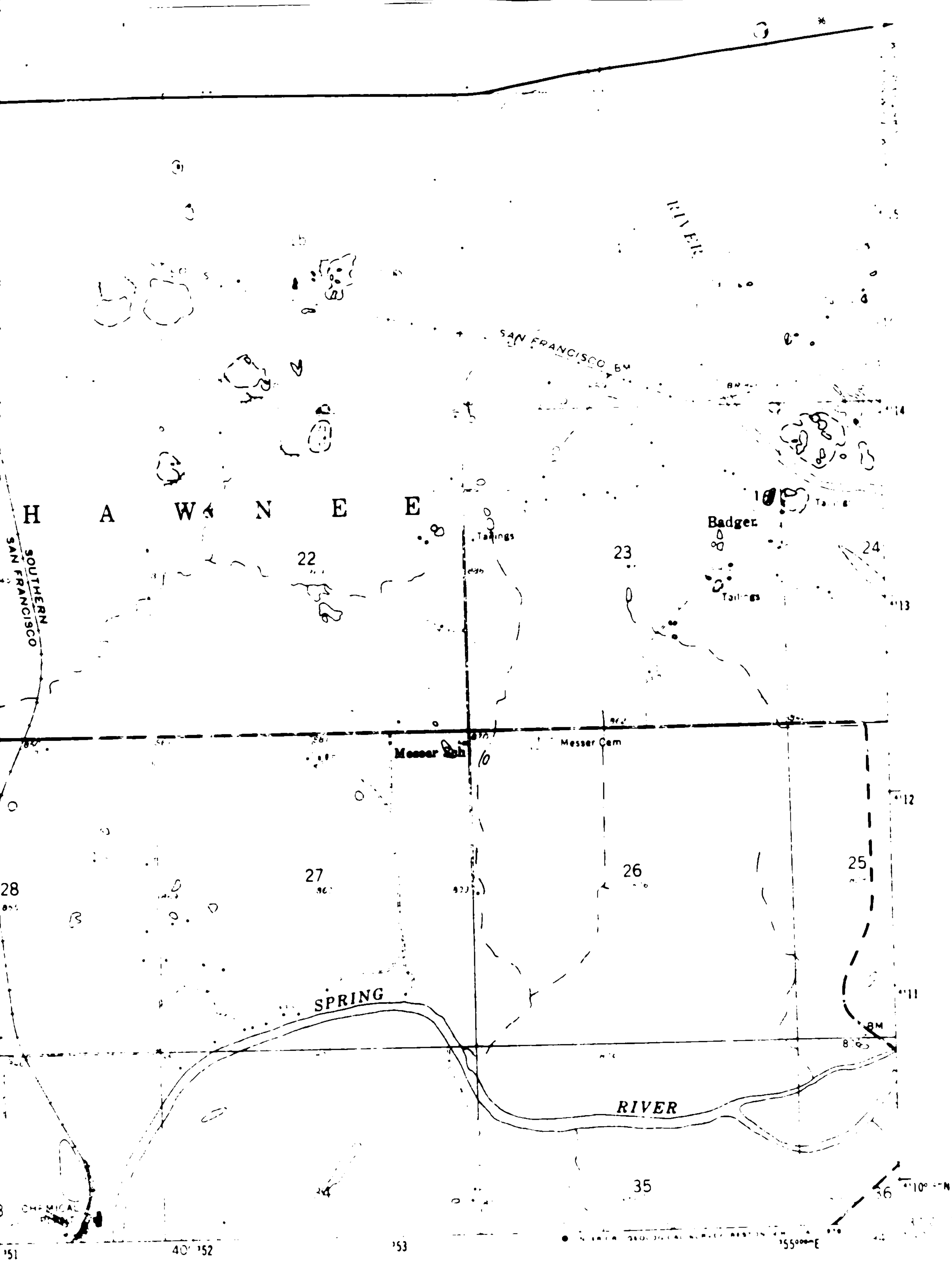
		Depth	Acres	yd^3
	R2	2 ft.	.07	226
	R3	1 ft.	.16	258
BS 2*	C1	5 ft.	5.40	43,559
	C2	2 ft.	1.73	5,582
	C3	3 in.	1.36	549
	R1	3 ft.	.33	1,597
	P1	30 ft.	.52	25,167
	P2	30 ft.	.20	9,680
BS13	C1/R1	3 in.	4.44	1,791

* Indicates a pile or location which was sampled

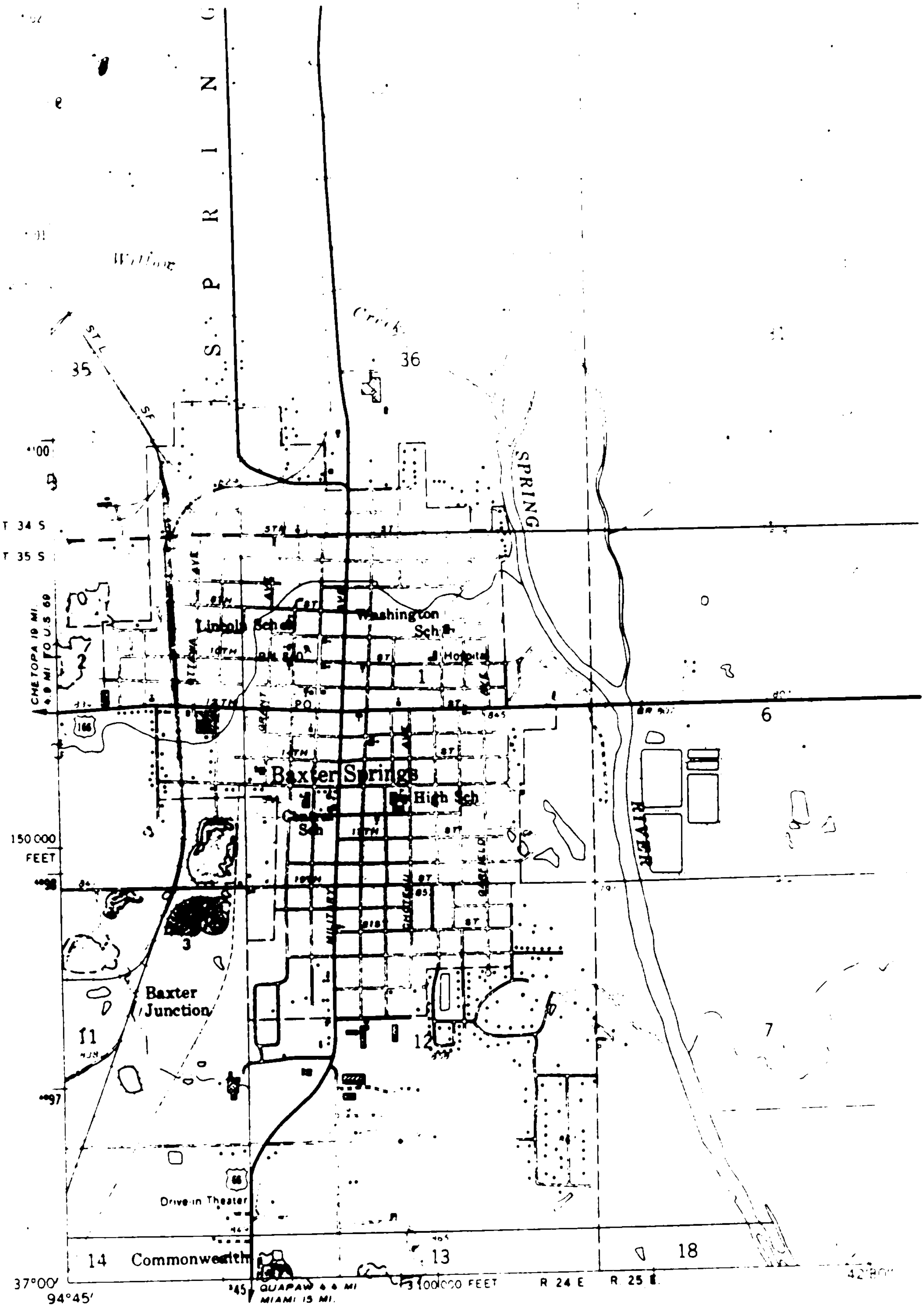
Appendix C

PLATE III-A: CRESTLINE QUADRANGLE, KANSAS





RIVER
SAN FRANCISCO BM
H A W N E E
SOUTHERN
SAN FRANCISCO
22
Tailings
23
Badger
24
Tailings
Messer Sch
Messer Cem
27
28
26
25
SPRING
RIVER
35
36
CHEMICAL
BM



SPRING
Willow
Creek
STL SF
35
36
T 34 S
T 35 S
CHETOPA 19 MI.
U.S. 69
Lincoln Sch
Washington Sch
Hospital
1
2
PO
6
166
Baxter Springs
High Sch
Central Sch
150 000 FEET
SPRING
RIVER
3
Baxter Junction
11
12
7
66
Drive-in Theater
14
Commonwealth
13
18
37°00′
94°45′
QUAPAW 4.6 MI
MIAMI 15 MI.
3 100 000 FEET
R 24 E
R 25 E
MN
GN

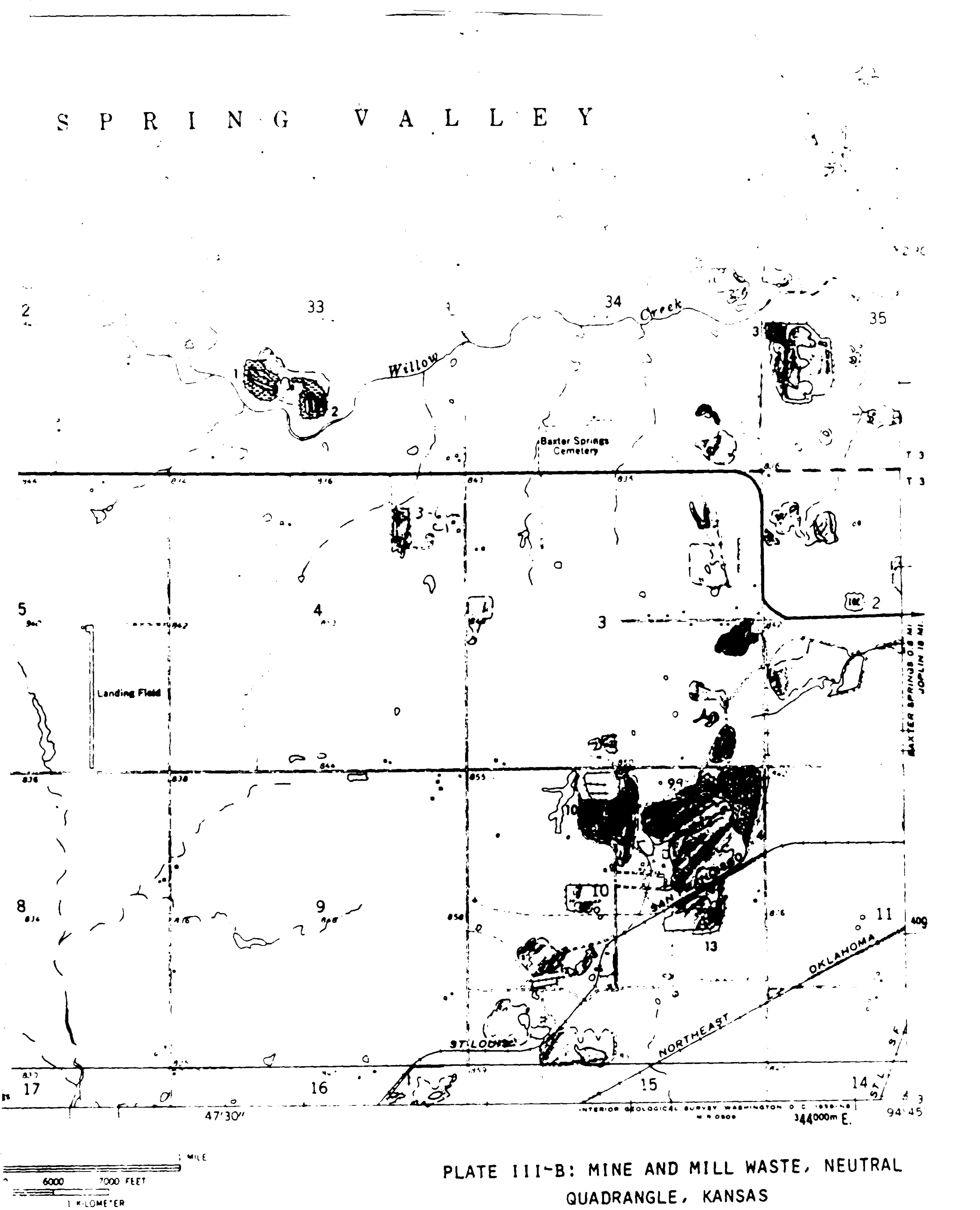
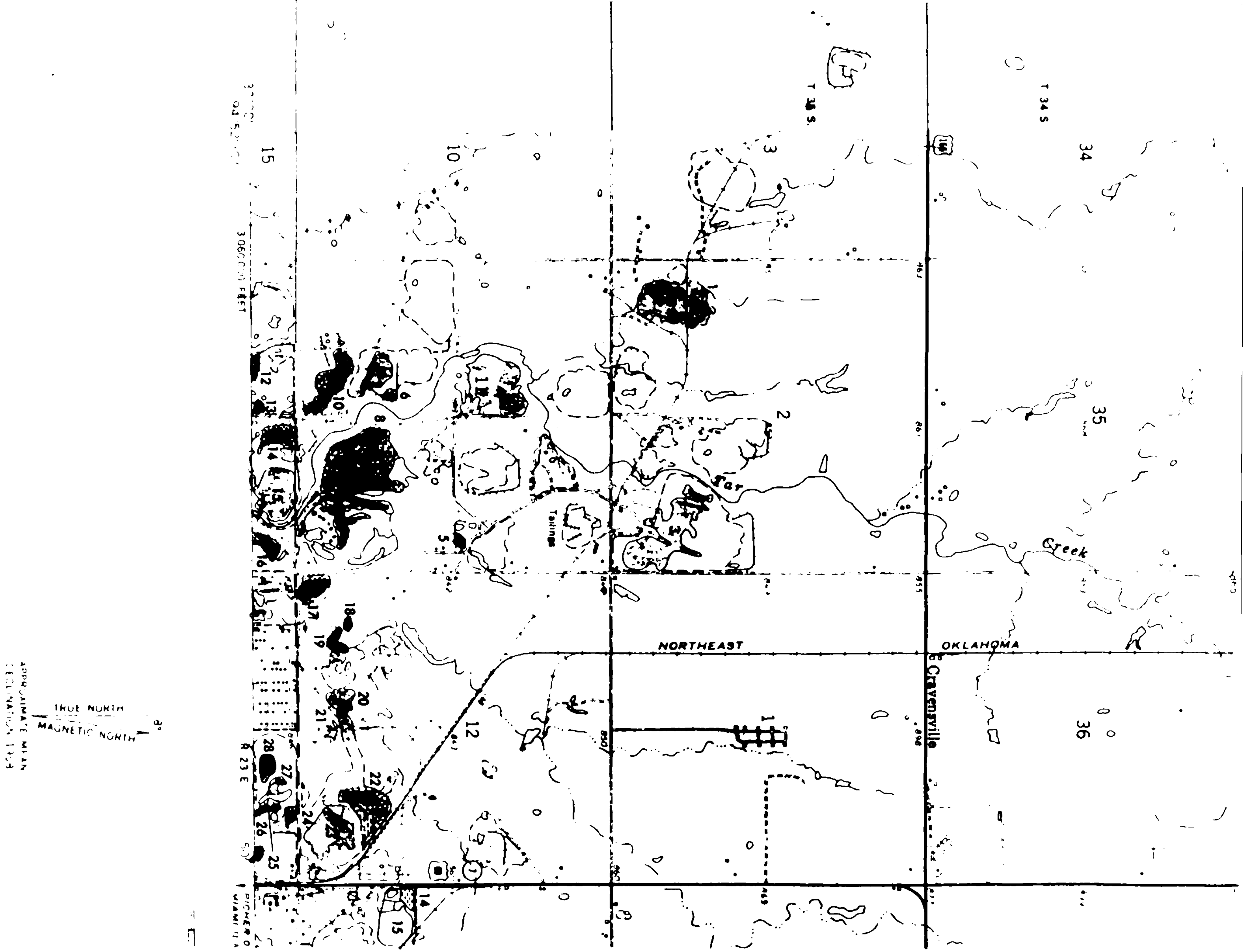
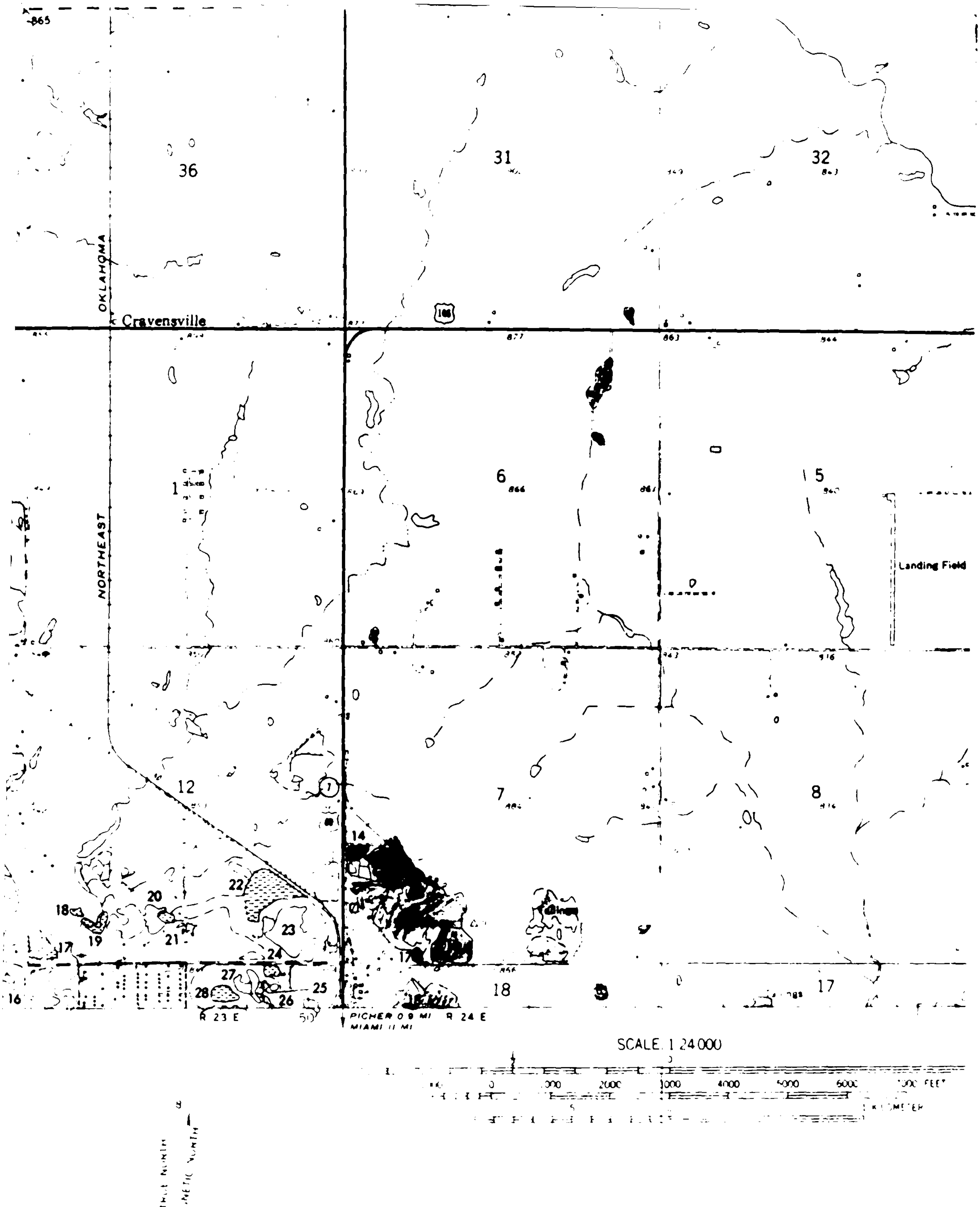


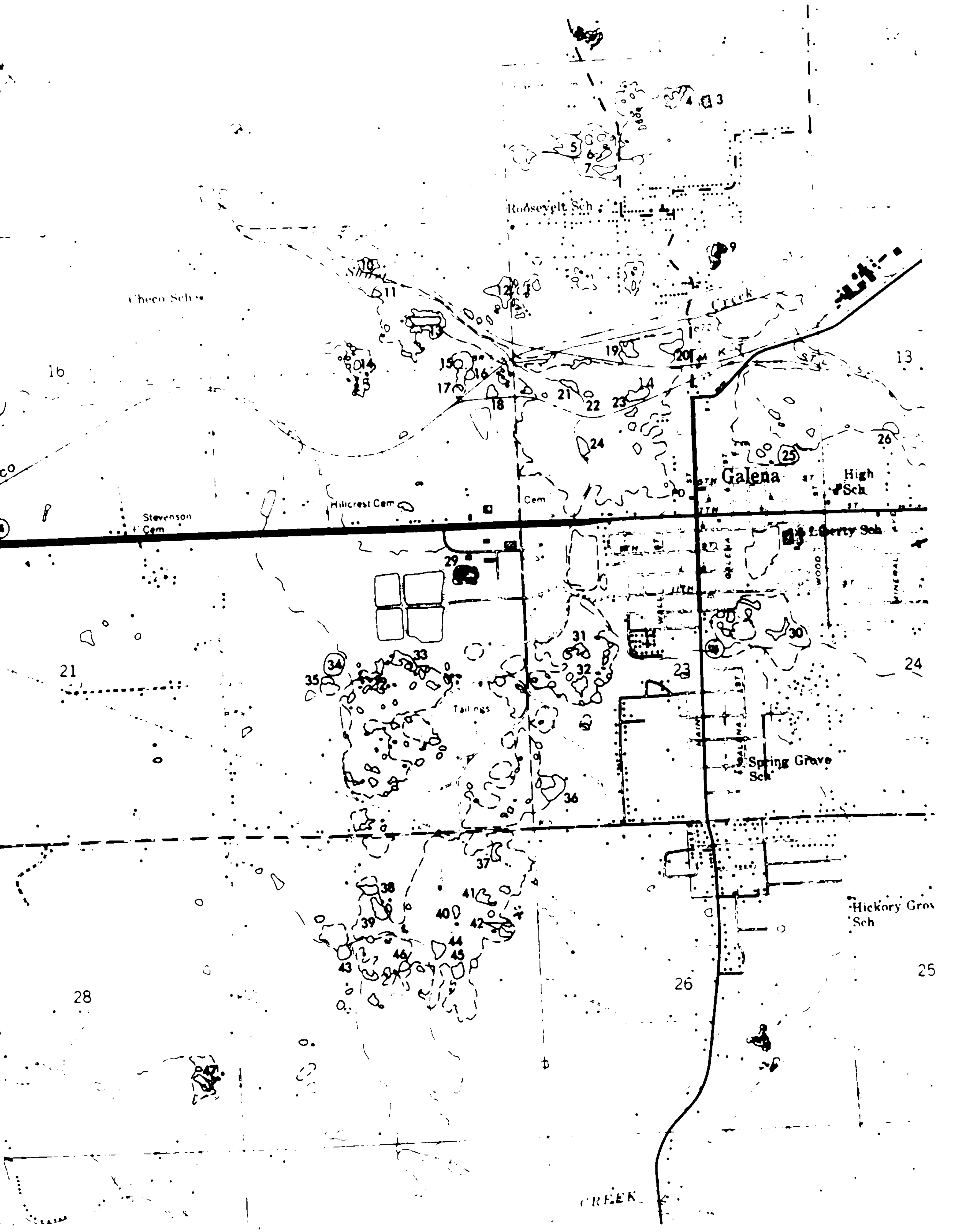
PLATE III-B: MINE AND MILL WASTE, NEUTRAL QUADRANGLE, KANSAS

BY JAMES R. MCCAULEY 1983

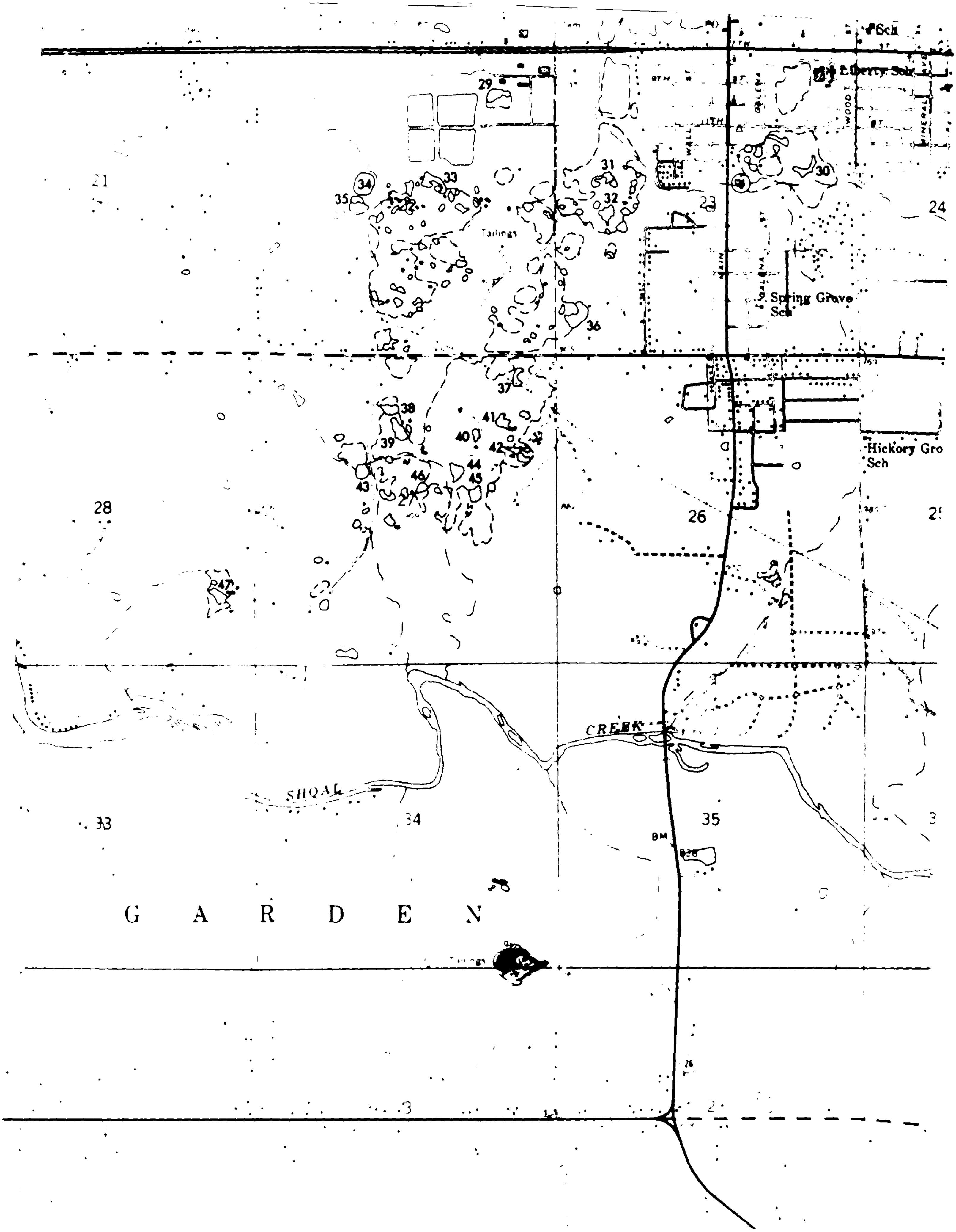

T 34 S
NORTHEAST
OKLAHOMA
Tar
Creek
Cravensville
Tailings
TRUE NORTH
MAGNETIC NORTH
R 23 E



MODIFIED AFTER U.S. GEOLOGICAL SURVEY BASE MAPS
NEUTRAL, KANSAS QUADRANGLE, 1958



Roosevelt Sch
Creek
Checo Sch
Galena
High Sch
Liberty Sch
Hillcrest Cem
Stevenson Cem
Cem
Tailings
Spring Grove Sch
Hickory Grov Sch
CREEK
16
13
21
24
23
28
26
25



Liberty Sch
Sch
29
31
32
33
34
35
30
21
23
24
Tailings
Spring Grove
Sch
36
37
38
39
40
41
42
43
44
45
46
47
Hickory Gro
Sch
28
26
CREEK
SHOAL
33
34
35
BM
G A R D E N
Tailings
3
2

Appendix D

List of Sampling Sites

Designation	Subsite Location	Township Range Section	Description
8A-C3	Galena	34,25,11	chat pile
5D-C1	Galena	34,25,15	chat pile
7B-C2	Galena	34,25,14	chat pile
7A-C2	Galena	34,25,13	chat pile
6B-C1S	Galena	34,25,15	chat pile (surface)
6B-C1SS	Galena	34,25,15	chat pile (subsurface)
G5-C1	Galena	34,25,22	chat pile
G6-C1	Galena	34,25,28	chat pile
G-GR1	Galena	34,25,26	chat from gravel road
1H-C10	Galena	34,25,27	chat pile
BS2-C1	Baxter Springs	35,24,13	chat pile
BS4-TSC1	Baxter Springs	35,24,11	chat, sand & tailing
BS8-C1	Baxter Springs	34,24,35	chat pile (Brewster)
BS10-T1	Baxter Springs	35,24,10	tailing pond and banks
BS10-C3	Baxter Springs	35,24,10	chat pile (Ballard)
T2-T3	Treece	35,23,11	tailing pond
T4-S2/C	Treece	35,23,14	sand/chat pile
T3-C7	Treece	35,23,2	chat pile
T2-C9	Treece	35,23,11	chat pile
T2-C11	Treece	35,23,11	chat pile
T5-C2	Treece	35,24,7	chat pile
T4-C1/S1	Treece	35,23,14	chat/sand pile
T2-C7	Treece	35,23,11	chat pile
T1-T1	Treece	35,23,2	tailing pond
T1-C2	Treece	35,23,2	chat pile
T15-T4	Treece	35,23,12	tailing pond
T15-C4	Treece	35,23,12	chat pile

Sampling Results
(Corrected for Dilution)

Sample	As	Ba	Cd	Cr	Cu	Fe	Mn	Ni	Pb	Zn
8A-C3	<0.001	0.0010	0.0005	0.007	0.0008	0.320	0.0006	0.001	0.024	0.0625
5D-C1	<0.001	0.002	0.001	0.008	0.008	0.410	0.002	0.0006	0.525	0.525
7B-C2	<0.001	0.002	0.002	0.009	0.004	0.450	0.003	0.0007	0.0572	0.655
7A-C2	0.001	0.001	0.002	0.013	0.002	0.405	0.002	0.0007	0.0287	0.588
6B-C1S	<0.001	0.0010	0.0010	0.006	0.0010	0.280	0.0006	0.0006	<0.003	0.194
6B-C1SS	<0.001	0.002	0.002	0.007	0.002	0.392	0.0007	0.0012	<0.003	0.330
G5-C1	<0.001	0.011	0.004	0.008	0.020	0.443	0.002	0.001	0.0450	0.928
G6-C1	<0.001	0.002	0.0005	0.007	0.001	0.318	0.0006	0.001	0.005	0.0665
G-GR1	<0.001	0.0010	0.002	0.009	0.001	0.350	0.010	0.0008	0.009	0.427
1H-C10	<0.001	0.002	0.0004	0.009	0.001	0.293	0.0007	0.0004	0.0605	0.0615
BS2-C1	0.002	0.0007	0.003	0.007	0.002	0.532	0.002	0.0008	0.171	0.520
BS4-TSC1	0.002	0.0004	0.002	0.009	0.003	0.365	0.001	0.0010	0.0622	0.425
BS8-C1	0.003	0.0007	0.004	0.012	0.015	0.555	0.008	0.0002	0.0378	1.08
BS10-T1	0.003	0.002	0.008	0.007	0.013	0.707	0.006	0.002	0.151	0.45
BS10-C3	0.002	0.0005	0.003	0.010	0.002	0.310	0.002	0.001	0.0282	0.53
T2-T3	0.003	0.001	0.006	0.008	0.013	0.755	0.016	0.002	0.510	1.38
T4-S2/C	0.003	0.0006	0.004	0.011	0.004	0.425	0.009	0.002	0.0407	0.782
T3-C7	0.003	0.002	0.006	0.011	0.003	0.285	0.002	0.001	0.0538	1.27
T2-C9	0.003	0.0006	0.004	0.011	0.004	0.390	0.008	0.001	0.0417	0.763
T2-C11	0.003	0.0006	0.006	0.014	0.004	0.457	0.006	0.002	0.014	1.34
T5-C2	0.003	0.0006	0.006	0.010	0.003	0.277	0.006	0.0010	0.0457	0.0010
T4-C1/S1	0.003	0.001	0.007	0.013	0.004	0.490	0.010	0.002	0.0475	1.55
T2-C7	0.003	0.0006	0.005	0.010	0.007	0.435	0.005	0.001	0.0705	1.06
T1-T1	0.002	0.0007	0.007	0.007	0.008	0.433	0.012	0.002	0.580	1.14
T1-C2	0.002	0.0006	0.007	0.007	0.005	0.385	0.007	0.001	0.0555	1.60
T15-T4	0.002	0.002	0.009	0.010	0.0257	0.690	0.023	0.002	0.443	1.64
T15-C4	<0.001	0.0007	0.004	0.016	0.004	0.380	0.008	0.0009	0.0607	0.700

Appendix E

Sampling Results
(Given in Percentages)

Sample	As	Ba	Cd	Cr	Cu	Fe	Mn	Ni	Pb	Zn
8A-C3	<0.001	0.0010	0.0005	0.007	0.0008	0.320	0.0006	0.001	0.024	0.0625
5D-C1	<0.001	0.002	0.001	0.008	0.008	0.410	0.002	0.0006	0.525	0.525
7B-C2	<0.001	0.002	0.002	0.009	0.004	0.450	0.003	0.0007	0.0572	0.655
7A-C2	0.001	0.001	0.002	0.013	0.002	0.405	0.002	0.0007	0.0287	0.588
6B-C1S	<0.001	0.0010	0.0010	0.006	0.0010	0.280	0.0006	0.0006	<0.003	0.194
6B-C1SS	<0.001	0.002	0.002	0.007	0.002	0.392	0.0007	0.0012	<0.003	0.330
G5-C1	<0.001	0.011	0.004	0.008	0.020	0.443	0.002	0.001	0.0450	0.928
G6-C1	<0.001	0.002	0.0005	0.007	0.001	0.318	0.0006	0.001	0.005	0.0665
G-GR1	<0.001	0.0010	0.002	0.009	0.001	0.350	0.010	0.0008	0.009	0.427
1H-C10	<0.001	0.002	0.0004	0.009	0.001	0.293	0.0007	0.0004	0.0605	0.0615
BS2-C1	0.002	0.0007	0.003	0.007	0.002	0.532	0.002	0.0008	0.171	0.520
BS4-TSC1	0.002	0.0004	0.002	0.009	0.003	0.365	0.001	0.0010	0.0622	0.425
BS8-C1	0.003	0.0007	0.004	0.012	0.015	0.555	0.008	0.0002	0.0378	1.08
BS10-T1	0.003	0.002	0.008	0.007	0.013	0.707	0.006	0.002	0.151	0.45
BS10-C3	0.002	0.0005	0.003	0.010	0.002	0.310	0.002	0.001	0.0282	0.53
T2-T3	0.003	0.001	0.006	0.008	0.013	0.755	0.016	0.002	0.510	1.38
T4-S2/C	0.003	0.0006	0.004	0.011	0.004	0.425	0.009	0.002	0.0407	0.782
T3-C7	0.003	0.002	0.006	0.011	0.003	0.285	0.002	0.001	0.0538	1.27
T2-C9	0.003	0.0006	0.004	0.011	0.004	0.390	0.008	0.001	0.0417	0.763
T2-C11	0.003	0.0006	0.006	0.014	0.004	0.457	0.006	0.002	0.014	1.34
T5-C2	0.003	0.0006	0.006	0.010	0.003	0.277	0.006	0.0010	0.0457	0.0010
T4-C1/S1	0.003	0.001	0.007	0.013	0.004	0.490	0.010	0.002	0.0475	1.55
T2-C7	0.003	0.0006	0.005	0.010	0.007	0.435	0.005	0.001	0.0705	1.06
T1-T1	0.002	0.0007	0.007	0.007	0.008	0.433	0.012	0.002	0.580	1.14
T1-C2	0.002	0.0006	0.007	0.007	0.005	0.385	0.007	0.001	0.0555	1.60
T15-T4	0.002	0.002	0.009	0.010	0.0257	0.690	0.023	0.002	0.443	1.64
T15-C4	<0.001	0.0007	0.004	0.016	0.004	0.380	0.008	0.0009	0.0607	0.700